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Sailing through the COVID-19 Pandemic and Beyond: An Evidence-Based Analysis for Dental Healthcare and Practice

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A B S T R A C T

This integrative review aims to provide a consolidated evidence-based appraisal of the most up-to-date guidelines and recommendations of international public and professional health regulatory bodies in relation to preparedness framework for restructuring safe delivery of dental services amid and beyond the coronavirus disease-2019 (COVID-19) pandemic. Most recent updated guidelines for dental professionals from major international health regulatory bodies were reviewed. PubMed, Google Scholar, Cochrane Central Register of Controlled Trials, WHO COVID-19 and LILACS databases, along with relevant preprints were searched, and citations were checked up to January 23, 2021. The search was performed by one author. Shortlisted articles were read and brought to consensus to be included in the study by at least two co-authors. In case of any disagreement between the judgements, an independent co-author's decision was taken as final. Of 849 records searched, 61 articles were included in the study. Following content analysis of the global guidelines and the collected prevailing evidence, the common themes and recommendations of different guidance documents were collated and summarized into seven domains. Most guidelines have a consensus regarding implementation of rigorous administrative, engineering and environmental infection control strategies. However, variations do exist with regard to the use of respirators in non-aerosol-generating procedure (non-AGP) settings, employment of airborne precautions during non-AGPs, use of supplemental air-handling systems, and preoperative use of mouthwashes. This evidence-based analysis can serve as a useful reopening resource tool and facilitate effective restructuring for delivery of optimal, equitable and safe dental practices globally, during and while emerging from the pandemic.

Keywords: COVID-19; Dentistry; Evidence-Based Dentistry; Risk Reduction Behavior

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INTRODUCTION

Ever since its emergence, the highly infectious coronavirus disease-2019 (COVID-19) caused by SARS-CoV-2 has left a tragic and catastrophic impact globally [1]. Even amid effective vaccine rollout rekindling hope of leading us out of the unprecedented global disaster, COVID-19 pandemic scourge continues unabated with

reports of highly transmissible multiple mutant variants such as SARS-CoV-2 VOC 202012/01 and 20H/501Y.V2 fueling further fear and anxiety [2].

Although the mechanisms are yet to be uncovered, increased prevalence of asymptomatic infections [3] and high transmissibility of COVID-19 from asymptomatic and pre-symptomatic patients have been reported to be a significant risk in rapid propagation of the pandemic [4, 5]. With the imminent increase in need for dental services in the immediate post-COVID-19 period [6], implications for resumption of routine dental care are enormous and cannot be ignored. Detection of SARS-CoV-2 in the saliva [7] and oral mucosa [8] of infected individuals necessitated placing dental healthcare professionals (DHCPs) and other medical personnel who perform aerosol-generating procedures (AGPs) in the "very high exposure risk" category [9].

The initial COVID-19 pandemic period saw a heightening of recommended safety standards including the mandatory utilization of personal protective equipment (PPE) and infection prevention and control (IPC) measures [10]. However, hurdles persist in implementation of routine dental care amid lack of evidence and lingering financial concerns [11]. Various international public health governing bodies have given their recommendations regarding a preparedness framework for provision of dental services during these turbulent times. This integrative review aims to provide a consolidated overview of these up-to-date guidelines, at the same time discussing and comparing these recommendations in context of the prevailing and emerging underpinning evidence.

MATERIALS AND METHODS

We reviewed the recommendations from recent up-to-date guidelines and communications from the following major international health regulatory bodies and departments of health with regards to the delivery of dental healthcare services: the US Center for Disease Control (CDC), National Health Services (NHS), European Center for Disease Prevention and Control (ECDC), Australian Government Department of Health (DHA), World Health Organization (WHO), and Ministry of Health and Family Welfare, India (MoHFW). Peer-reviewed English language publications were also retrieved from the PubMed, Google Scholar, Cochrane Central Register of Controlled Trials, WHO COVID-19 and LILACS databases. The search was updated on January 23, 2021 to identify new studies. Additionally, relevant preprints listed in bioRxiv, medRxiv, and SSRN platform operated by Cold Spring Harbor Laboratory were also searched and reviewed. The references of all policy documents and included studies were also screened for eligible literature.

Search strategy, screening and selection of studies:

The search strategy comprised the following free-text keywords: ''Coronavirus'', or ''COVID-19'', or ''SARS-CoV-2,'' or "2019-nCoV", ''transmission,'' ''dentistry", "practice", "reopening", "transmission", ''infection prevention and control'', "personal protective equipment", ''treatment,'' "disinfection", "ventilation", "communication", "dental procedures", "risk assessment", "risk reduction", and ''protocol.'' The search strategy was performed by one single author. The shortlisted papers were read and brought to consensus to be included in the study by at least two co-authors. In case of any disagreement between the judgements, an independent co-author's decision was taken as final.

Inclusion criteria:

(i) Guidelines for dental professionals from major international health regulatory bodies and departments of health which are commonly used as a reference globally.

(ii) Study methodology/design: Clinical, in-vitro laboratory/experimental/modelling studies, epidemiological studies, reviews (systematic, integrative, and rapid), meta-analyses, randomized controlled trials (RCTs), qualitative studies, non-clinical reports, and other relevant original research related to COVID-19 transmission and control strategies.

(iii) Types of settings - dental practices (private/institutional), hospital settings where dental procedures and investigations are conducted, including simulated environments mimicking dental settings.

Exclusion criteria: Study design not relevant to COVID-19 transmission, case reports, case studies, opinions, perspectives or personal communications, letter to editors, editorials, commentaries, and non-English language articles.

Data management and analysis:

Once the information from the guidelines was sourced and verified, it was reviewed in context of the emerging underpinning evidence. The common categories included in dental reopening guidelines of major healthcare bodies across the globe were identified [12], and recommendations were clubbed into various domains to structure our analysis. A content analysis of the data was then performed and summarized.

RESULTS

Of a total of 849 records identified, 61 articles were finally included in the study (Figure 1).

Summary findings of content analysis:

The common themes and the relevant recommendations of the different guidance documents were summarized in seven domains (Table 1).

I. Dental Operatory Settings: All sources [13-18] provide guidance regarding the use of appropriate PPE, donning-doffing sequence, single sessional use/extended use, avoiding PPE overuse and maintaining supply chains.

1) Cross-infection control*:*

All sources [13-18] recommend robust infection control measures through trans-mission-based precautions (contact, droplet, and airborne) in addition to standard infection control precautions (SICPs) during AGPs and during treatment of suspected/confirmed COVID-19 patients. However, one source [14] categorically recommends that only SICPs may suffice even during AGPs performed in the low-risk treatment pathway, and that airborne precautions are necessitated during AGPs in the medium and high-risk pathways.

DHA [16] suggests that in addition to SICPs, contact and droplet precautions may suffice for clinical consultation and examination of suspected patients. Two sources [13,16] recommend that in non-AGP settings, only SICPs may be sufficient for treating unsuspected patients and recovered patients who have completed home isolation.

Two sources [13,19] recommend that emergency AGPs in suspected/confirmed cases should be performed in negative pressure/airborne infection isolation rooms (AIIRs).

Evidence related to cross-infection control (transmission pathways):

Recent emerging evidence [20,21] acknowledges the potential for airborne transmission, particularly in enclosed and poorly ventilated spaces with re-circulating air conditioning systems [22]. Experimental studies utilizing high-powered jet nebulizers demonstrated presence of SARS-CoV-2 virus RNA within aerosols for up to 3 hours [23] and for up to 16 hours [24].

Studies have also demonstrated the presence of SARS-COV-2 RNA in hospital air samples [25], and of seasonal coronavirus RNA in fine aerosolized particles during tidal breathing [26]. However, in the absence of demonstrable viability, replicability and infectivity of the recovered virions in the air in non-AGP settings from available hospital studies [27,28], airborne mode of transmission continues to be debated. Since infections cannot be clearly demarcated into droplet or airborne type, urgent high-quality research is needed to elucidate mechanisms shaping transmission distances, the role of airborne transmission in the absence of AGPs, viral doses required for transmission to occur, the settings and risk factors for super-spreading events, and the extent of asymptomatic and pre-symptomatic transmission [29].

2) Hand hygiene:

All sources [13-15,17,18,30] advise adherence to the WHO's '5 moments' of hand hygiene for at least 20s, and alcohol-based hand rubs (ABHR) with at least 60% ethanol or 70% isopropanol for visibly clean hands.

DHA specifically recommends using ABHRs meeting more suitable and stringent European EN 1500 standards with greater safety margin and demonstrating greater antimicrobial activity within 30s [30].

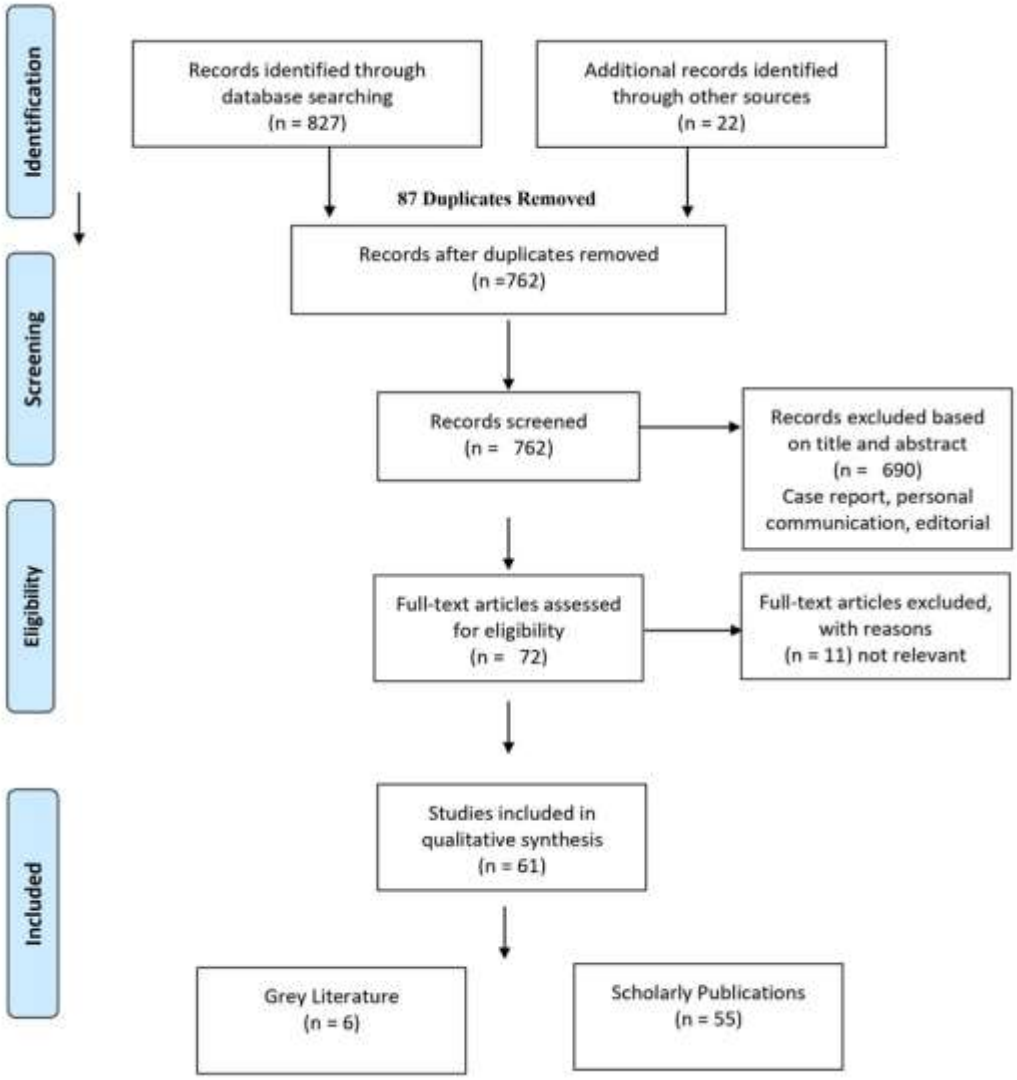

Fig. 1. Flowchart depicting study selection in accordance with PRISMA guidelines

The important features for enhancing the acceptability of the ABHR include the use of emollients, absence of fragrance and color, drying characteristics (preferring solutions over gels) and absence of any skin irritation or dryness [30]. Use of specific 'Hand Hygiene' audit template has been suggested for monitoring and ensuring full compliance with hand hygiene procedures [30].

Evidence of hand hygiene effectiveness against SARS-CoV-2:

Kratzel et al. [31] demonstrated efficient SARS-CoV-2 inactivation by use of original and modified WHO-recommended hand rub formulations I and II, ethanol and 2-propanol at concentrations of ≥30% .

The authors recommend at least 30s duration for virus inactivation as compared to generally recommended duration of 20s. Based on the real-time data in hospital settings, Kenters et al. [32] recommended the use of a minimum of 2.25ml for gel-based ABHR, and 1.5ml for foam-based formulations to achieve a >80% hand coverage in less than 30s. The authors [32] recommend the need for deploying correct pump volumes and revisiting the needed drying time to achieve acceptable antimicrobial efficacy of ABHRs.

Table 1: Summary of findings

Variable	Guideline Issuing Organization					
	CDC	NHS	ECDC	DHA	MoHFW	WHO
I. PRACTICE PREPARATION & PRACTICE SETTING STRATEGIES						
1. Reducing contamination risk in waiting area/station/reception	✓	✓	✓	✓	✓	✓
2. Physical Distancing	6 feet/2m	2m or 1m + additional precautions	At least 1.5m (ideally 2m)	1.5m	1m	1m
3. Equipment considerations **- Dental Unit Waterlines** **- Vacuum & suction lines** **- Testing of autoclaves & instrument cleaning equipment**	Ensuring water quality (<500 CFUs/ml)	✓			✓	
4.Ensuring essential supplies of personal protective equipment	PPE Burn Rate Calculator [Excel based 3-sheet]; NIOSH PPE Tracker app for average PPE consumption/burn rate	✓	✓	✓	✓	WHO COVID-19 Essential Supplies ForecastingTool[b]
5. Staff preparation	✓	✓	✓	✓	✓	
- Advice, screening, support & well-being		1-2-1 wellbeing check-in template; 'Covid-Age' tool by ALAMA[c]			40min teleyoga module: Breathing techniques (Prānāyāma; 30min) & Relaxation (10min)[d]	
- Mental well-being online support resources		- 'Every Mind Matters' initiative - MIND UK - Silver Cloud		-Phoenix Australia -Head to Health - Lifeline -Beyond Blue		
- Anxiety reduction support applications	- Headspace, - Breathe2Relax - Happify - Anxiety Coach	- Unmind - Headspace - Sleepio - Daylight				

Variable	Guideline Issuing Organization					
	CDC	NHS	ECDC	DHA	MoHFW	WHO
6. Return to work criteria (after self-isolation)						
(i) For staff with confirmed COVID-19 - Elapsed time period after symptom onset	10d for mild to moderate illness, at least 10d & up to 20d for severe to critical illness/immune-compromised staff	10d	10d for mild cases, 14-20d for severe cases	10d	10d + further 7d for self-monitoring	10d
- Elapsed time since being afebrile without the use of antipyretics & without respiratory symptoms	At least 24h + improvement of symptoms	At least 48h	At least 3d	At least 72h	At least 3d	At least 3d
(ii) For staff in contact with confirmed COVID-19 cases (close contacts)	14d	14d	14d	14d	14d	14d
7. Patient triage, screening & evaluation	COVID Symptom Tracker App	COVID Symptom Tracker App/ NHS COVID-19 App	✓	COVIDSafe App	Arogya Setu App	✓
II. PATIENT ASSESSMENT & CARE PATHWAYS						
1. Patient communication & scheduling/care pathways	Phone Advice Line Tool[e] for possible COVID-19 patients	✓	✓	✓	✓	✓
2. Classification of risk assessment/ categorization		✓		✓		

Variable	Guideline Issuing Organization					
	CDC	NHS	ECDC	DHA	MoHFW	WHO
III. PPECONSIDERATIONS FOR DHCP (DENTAL SURGEON & AUXILIARY STAFF)						
1. Filtering half-masks/respirators, N95 or equivalent respirators for AGPs	✓	✓	✓	✓[f]	✓	✓
- Performance standards of filtering half-masks/respirators	National Institute for Occupational Safety & Health certified N95 (NIOSH-42CFR84)	European Standard Filtering Face Piece 2 or 3 (Europe EN 149-2001) (EU FFP2/FFP3	European Standard Filtering Face Piece 2 or 3 (Europe EN 149-2001) (EU FFP2/FFP3	P2(Australia/New Zealand AS/NZA 1716:2012)	N95 respirator	N95 or FFP2 respirator
2. Type IIR fluid resistant surgical masks for non-AGPs	✓	✓	✓[g]	✓	✓	✓
3. Fluid resistant long-sleeved disposable gowns/ coveralls	✓	✓	✓	✓	✓	✓
4. Gloves	✓	✓	✓	✓	✓	✓
5. Goggles/Visor	✓	✓	✓	✓	✓	✓
6. Proper donning-doffing sequence	✓	✓	✓	✓	✓	✓
IV. DENTAL OPERATORY SETTINGS						
1. Cross-infection control						
- Standard precautions	✓	✓	✓	✓	✓	✓
- Contact & droplet precautions	✓	✓	✓	✓	✓	✓
- Airborne precautions for AGPs	✓	✓	✓	✓	✓	✓
- Airborne precautions for non-AGPs		✓				

Variable	Guideline Issuing Organization					
	CDC	NHS	ECDC	DHA	MoHFW	WHO
2. Hand hygiene						
- Hand Wash	✓	✓	✓	✓	✓	✓
- Alcohol-based hand rubs	At least 60% alcohol	70% ethyl alcohol	Not specified	60-80% ethanol/ Conforming to European Standard EN 1500 standards	Not specified	60-80% alcohol
3. Engineering controls						
(i) Ventilation/air handling systems	✓	✓	✓	✓	✓	✓
(ii) Supplemental air handling systems						
- HEPA filters	✓		✓	✓	✓	✓
- Microbicidal UVGI systems	✓				✓	
(iii) Strategic patient positioning	✓					
V. DENTAL PROCEDURAL CONSIDERATIONS						
1. Risk assessment for DHCP		Low risk pathway; Medium risk pathway; High risk pathway		Low risk: treatment of a patient ± expo-sure to a known COVID-19 case; Moderate risk: treatment of a patient + expo-sure to a suspected COVID-19 case; High risk: treatment of a patient + expo-sure to known COVID-19 case; Very high risk: treatment of COVID-19 case	Moderate risk; High risk; Very high risk	

Variable	Guideline Issuing Organization					
	CDC	NHS	ECDC	DHA	MoHFW	WHO
2. Risk reduction interventions	✓	✓	✓	✓	✓	✓
-Sequencing & scheduling considerations for vulnerable & suspected/confirmed cases	✓	✓	✓	✓		
3. Preprocedural mouth rinses	Chlorhexidine gluconate, essential oils, PI, cetylpyridinium chloride				10 ml of 0.5% PI for 1min	1% hydrogen peroxide or 0.2% PI for 20s
VI. POST-TREATMENT DISINFECTION/STERILIZATION/WASTE MANAGEMENT RECOMMENDATIONS						
1. Disinfectant products	Environmental Protection Agency registered List N hospital grade (NaOCl, etc)	NaOCl, EN standards 14476 virucidal agents	NaOCl, 70% ethanol, Biocidal Products Regulation (EU) 528/2012 registered virucidal agents	NaOCl, therapeutic goods administration-listed	NaOCl, 60-90% alcohol	NaOCl, 70% ethanol
2. Concentration of Sodium hypochlorite for disinfection of						
- Clinical surfaces (non-porous)	If contaminated with blood, small spills (<10ml: 525-615 ppm, 1:100 dilution[h])	0.1% (1000 ppm of available chlorine (av.cl.) with contact time of 10 minutes)	0.05% (5% initial concentra-tion diluted to 1:100)	0.01% (contact time of 10min)/ 0.1% (contact time of 1min)	1% (contact time of 10min)	0.1% (1000 ppm) 1min contact time
- Reusable patient care equipment[i]	If contaminated with blood, small spills (>10ml: 525-615ppm, 1:10 dilution initially, followed by 1:100 dilution[h])	If contaminated with blood – 10,000 ppm avl. cl.; with vomit or used on suspected/ confirmed patient – 1000 ppm avl. cl.				0.5% (5000 ppm) for large blood or body fluid spills (i.e. more than about 10 ml)
- Cleaning equipment (mops, mop handles, buckets, & cloth/sponges) & toilets		0.1%	0.1%	0.01%	1%	
3. Sterilization & disinfection of dental instruments & supplies	✓	✓		✓	✓	✓

Variable	Guideline Issuing Organization					
	CDC	NHS	ECDC	DHA	MoHFW	WHO
4. Infected waste management						
Clinical waste handling (disposal/transport) regulations	Veterans Affairs	Health Technical Memorandum 01-07 guidelines	In accordance with healthcare facility policies & local regulations	Standard AS/NZS 3816: 2018	Indian Health Service, CPCB Biomedical Waste Management Guidelines	WHO Guidelines[k]
VII. ESTABLISHING COMMUNICATION, TRAINING & INFORMATION SYSTEMS						
1. Remote consultations, communications, staff training & support considerations (virtual web platforms- Skype, WhatsApp, Facetime, & Microsoft Teams, HIPAA compliant Zoom, Go To Meeting, Uber Conference, Skype, Google Hangouts, FaceTime, Duo, MS Teams	✓	- "Hospify" application, "Attend Anywhere" digital platform - "Brush DJ" app [www.brushdj.com]	✓	✓	✓	✓
2. Resources for information dissemination to public		✓				

CFU: Colony forming unit; PPE: Personal protective equipment; NIOSH: National Institute for Occupational Safety and Health; ALAMA: Association of Local Authority Medical Advisors; d: days; h: hours; PI: povidone iodine

a. https://www.cdc.gov/coronavirus/2019-ncov/hcp/ppe-strategy/burn-calculator.html
b. WHO COVID-19 Essential supplies forecasting tool (ESFT)-COVID, version 3. World Health Organization. https://apps.who.int/iris/handle/10665/333984.
c. https://alama.org.uk/covid-19-medical-risk-assessment/
d. https://www.mohfw.gov.in/pdf/COVID19Final2020ForOnline9July2020.pdf
e. https://www.cdc.gov/coronavirus/2019-ncov/hcp/phone-guide/index.html
f. Only during treatment of confirmed COVID-19 patients
g. Only if FFP2/ FFP3 respirators are not available
h. https://www.cdc.gov/infectioncontrol/guidelines/disinfection/recommendations.html
i. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachmentdata/file/910594/Final appendix 2 IPC 19082020.pdf
j. https://www.cpcb.nic.in/uploads/Projects/Bio-Medical-Waste/BMW-GUIDELINES-COVID.pdf
k. Safe management of wastes from health-care activities: a summary. Geneva: World Health Organization; 2017 (WHO/FWC/WSH/17.05)

3) Engineering controls:

(i) *Ventilation/air changes per hour (ACH)/air-handling system considerations:*

The WHO guidelines recommend a minimum hourly average ventilation rate of 60 L/ per patient for the dental operatory/outpatient clinic, and of 160 L/s per patient (with a minimum of 80 L/s/patient) for airborne precaution rooms [33].

Four sources [10, 18, 34, 35] lay emphasis on ensuring natural ventilation by frequent opening of windows for at least 15 minutes in neutral pressure rooms.

Heating, ventilation, and air conditioning (HVAC) systems play an important role in decreasing transmission in indoor spaces by allowing higher air change rates, decreasing recirculation of air, and increasing the use of outdoor air fractions. Improvement of mechanical ventilation has been recommended through the implementation of the following measures: placement of supply-air vents in reception or corridor area and return-air vents in the waiting area or rear of the patient operatory, thereby allowing air flow from the clean area into the less clean area [13], limiting the use of energy-saving settings such as demand-controlled ventilation during occupied hours and extending the operating times of HVACs before and after the regular period [34, 36], use of an independent exhaust blower to extract the room air into the atmosphere [17], use of a table fan behind the operator to allow airflow towards the patient [18], and continuous use of the bathroom exhaust fan during clinic hours [13,34]. The MoHFW [18] advises partial opening of windows during fan operation, and not using ceiling-mounted fan units during the procedure. On the contrary, NHS [14] recommends the use of properly directed extractor fans (not towards doors), fixed-split and portable air conditioning (without recirculation) without incorporated humidifiers. The WHO [17] also recommends employing hybrid (mixed-mode) ventilation by installing "whirlybirds" (whirligigs or wind turbines) not relying on electricity and providing a roof exhaust system to increase airflow.

The CDC [13] provides the following instruction form for maintenance of AIIRs: Venting of the air directly to the external environment or filtration through an integrated high efficiency particulate air (HEPA) filter directly before recirculation, keeping room doors closed to prevent viral spread, minimizing entry and exit, and regular monitoring and documentation of the proper negative-pressure function of these rooms.

(ii) Supplemental air handling systems: Five sources [13, 17, 18, 30, 34] recommend the use of portable HEPA filtration units. The CDC [13] specifically recommends the use of HEPA filters (placed adjacent to the patient's chair, but not behind the DHCP) with high 'clean air delivery rate' to increase the effectiveness of the turnover time.

The effectiveness of ultraviolet germicidal irradiation (UVGI) technology has been well established against the SARS-CoV-1 virus [37]. Two sources [13, 18] recommend the use of UVGI as an adjunctive multi-barrier approach to higher ventilation and air cleaning rates. Considering the potential exposure concerns, the UVGI can be safely installed in mechanical ventilation paths or in upper-room applications wherein air is treated indirectly through convective air movement [38].

Evidence-based recommendations:

Based on the direct evidence derived from in-vitro studies with SARS-CoV-2 [39] and other endemic airborne alpha HCoV-229E and beta HCoV-OC43 human coronaviruses with similar genomic sizes as SARS-CoV-2 [40], the use of regulated low-dose-rate single wavelength far-UVC light at 222 nm generated by a krypton-chloride filtered excimer lamp has been recently proposed as a promising disinfection alternative to 254 nm (or higher) conventional UVGI, with minimal penetrative effects on biological human tissues. However, further research is warranted to verify the margin of safety before implementation in a real-world clinical setting.

(iii) *Strategic patient positioning:* Based on feasibility, the CDC [13] recommends provision of dental treatment in individual patient rooms. In operatory rooms with open floor plans, ensuring at least 6 feet space

between dental chairs, positioning the patient's head near the return air vents and away from people passing by in the halls, and orienting the operatory parallel to the direction of airflow helps prevent cross-infection. Easy to clean floor-to-ceiling physical barriers between dental chairs not interfering with fire sprinkler systems help enhance effectiveness of portable HEPA systems. If feasible, in vestibule-type operatory rooms, the patient's head should be preferably positioned towards the rear wall [13].

II. Dental Procedural Considerations

1). Risk assessment considerations:

In the scenario of low community transmission, DHA [41] outlines risk assessment based on probability of exposure and level of contact with the potential source of infection. The NHS [10] categorized dental care involving non-AGPs as part of the medium risk pathway, and treatment involving AGPs as part of the high-risk care pathway. Based on the clinical condition/procedures, the MoHFW [18] has classified dental procedures as moderate, high, or very high risk (Table 1).

Evidence pertaining to risk assessment:

Ren et al. [42] estimated the annualized risk for DHCP in the United States during the current pandemic and found very low inherent risk of 0.008% of contracting COVID-19 from asymptomatic patients. The authors also found the risk estimate to be highly age-dependent, with risks almost approaching zero under the age of 40 years [42].

Evidence related to aerosol production and associated risk assessment:

In a recent systematic review, Innes et al. [43] proposed a hierarchy of contamination risk from different procedures; wherein, procedures such as ultrasonic scaling, high-speed air-rotor, air-water syringe (air only or air/water together), air polishing, and extractions using motorized handpieces were classified as high risk; use of slow-speed handpieces, prophylaxis with pumice and extractions as being moderate risk, and use of air-water syringe (water only) and hand scaling as low risk procedures.

A rapid review by Health Protection Scotland [44] identified weak evidence supporting the generation of infectious aerosols during dental procedures. However, it found moderate evidence that ultrasonic scaling and drilling produces respirable aerosols.

2). Risk reduction/mitigation interventions:

All sources provide the following recommendations for reducing risks during dental procedures: Avoiding or restricting AGPs whenever possible, by the use of manual instead of automated instruments driven by compressed air, limited scheduling of patients, limiting the staff during procedure, avoiding the use of spittoons, and using rubber dams and high-volume evacuation during AGPs. One source [18] recommends using handpieces with anti-retraction valves. Four sources [10, 13,17,18] include recommendations for practicing 4-handed dentistry. While considering an exposure of 15 minutes or more to be a prolonged one, and also any duration while performing AGPs to be prolonged, CDC [13] recommends that minimally invasive/atraumatic restorative techniques should be prioritized, and treatment appointments should be short, particularly first post-quarantine appointments. Two sources [10,17] recommend prioritizing single-visit procedures.

(i) Preventive and non-AGP caries management recommendations: The NHS [10] emphasizes on implementation of the concept of 'advanced minimally invasive restorative dentistry' involving (a) non-invasive prevention of inactive carious lesions by oral hygiene reinforcement and dietary control advice, and non-AGP mineralization control by application of fluoride varnishes, and calcium phosphate containing pastes; (b) micro-invasive caries management for early, non-cavitated, active carious lesions using preventive/therapeutic sealants and resin infiltration, and (c) minimally invasive restorative management of active cavitated, deep carious lesions using risk-mitigated AGP principles.

In pediatric patients, minimally invasive oral healthcare involving the use of silver diamine fluoride and Hall crowns, and where appropriate considering extractions over traditional conservative approaches have

been recommended for primary dentition [10, 17]. In permanent dentition cases, temporization and stabilization for a six-month period have been recommended. The NHS [10] provides advice for inhalation sedation (nitrous oxide) as a suitable alternative to general anesthesia.

(ii) Non-AGP periodontal recommendations: In accordance with the European Federation of Periodontology S3 Level Clinical Practice Guidelines [45] reporting similar outcome with ultrasonic/sonic instruments and hand instruments for treatment of stage I–III periodontitis, the use of non-AGP instruments (hand scaling and hand curettes) instead of sonic/ultrasonic scaling devices has been recommended.

(iii) Dental radiography considerations: Since intraoral radiographs like IOPA or occlusal views can stimulate the gag reflex and induce coughing, use of extraoral radiographs such as orthopantomograms and cone-beam computed tomography has been suggested as appropriate alternatives. Utilization of teleradiology systems has been recommended to prevent contamination when practicing dental radiography during the COVID-19 pandemic [46].

(iv) Scheduling considerations for vulnerable and suspected/confirmed cases:

Three sources [10,13,15,16] recommend scheduling of emergency treatment for suspected/confirmed cases at the end of the day in individual patient rooms with the door closed.

The NHS [10] provides the following specific guidance regarding urgent treatment provision for clinically and extremely vulnerable patients: morning scheduling to allow maximum time for air clearance/ventilation overnight, treatment in a separate room with minimum staff, or treatment provided with a domiciliary visit by a dedicated dental team if clinically appropriate.

Evidence regarding mitigation of transmission risk:

The majority of dental operatory rooms are neutral pressure rooms, and are generally not designed as AIIRs. The current evidence shows that in the absence of AIIRs, utilization of well-resourced PPE alone (handwashing, gloves, goggles, face shields, N95 face masks, and protective gowns) may mitigate the transmission risk by approximately 90% [47]. However, considering the potential risk of infection from every patient, the concept of SAFER Dentistry (safe aerosol-free emergent dentistry) has been proposed [48]. A recent Cochrane systematic review of 16 studies with 425 participants found that the evidence of the beneficial effects of high-volume evacuator, rubber dam, dental isolation combination system, air-cleaning systems, and antimicrobial coolants is of very low certainty, thereby necessitating further studies to draw a more conclusive real-life evidence [49].

Evidence supporting the effectiveness of nonrestorative treatments for carious lesions:

The effectiveness of non-restorative and non- or micro-invasive caries treatment (fluoride- and non-fluoride based interventions) involving the use of 5% sodium fluoride varnish and 38% silver diamine fluoride solution was demonstrated in a recent network meta-analysis by Urquhart et al [50].

3) Pre-procedural mouth rinses:

Owing to high viral load in the oropharynx of asymptomatic patients with SAR-SCoV-2 infection [51], three sources [13,17,18] recommend the use of mouthwashes such as chlorhexidine gluconate, hydrogen peroxide, essential oils, povidone-iodine (PVP-I) or cetylpyridinium chloride to reduce the risk of direct transmission (Table 1).

Direct evidence consistently supports the use of PVP-I:

In-vitro virucidal efficacy of 0.5% PVP-I and 1.0% PVP-I oral rinse after a contact time of 15s, and 1.0% PVP-I oral rinse and 0.45% PVP-I throat spray after a 30-second contact time has been recently demonstrated in separate studies [52,53,54].

Meister et al. [55] demonstrated that mouth formulations containing 1% PVP-I, combination of dequalinium chloride and benzalkonium chloride, and combination of ethanol and essential oils can significantly reduce viral infectivity to undetectable levels within short exposure times of 30s in vitro.

However, a chlorhexidine based mouth-rinse exhibited weak virucidal efficacy. In a recent sole RCT, Seneviratne et al. [56] found that rinsing with 0.075% cetylpyridinium chloride and 0.5% PVP-I for 30s decreased the salivary SARS-CoV-2 levels within 5 minutes of use, and the subsequent effects were sustained for 3 hours and 6 hours. A recent network meta-analysis involving aerosol mitigation intervention processes reported 0.2-1% PVP-I or 1% hydrogen peroxide to be an effective substitute for oxidation-prone vulnerable viruses such as SARS-CoV-2 [57].

Considering the emerging evidence demonstrating in vitro and in vivo virucidal efficacy of PVP-I, it seems justified to recommend the use of PVP-I for interrupting direct SARS-CoV-2 transmission. The recommendations of Kirk-Bailey et al, [58] regarding the use of 9 ml of 0.5% PVP-I as a mouthwash both for the patient and for the clinical staff repeated every 2-3 hours up to 4 times a day, can be followed. The authors also recommend the intranasal application of 0.28-0.3 ml of 0.5% PVP-I solution into each nostril to minimize bio-aerosols from the nasal cavity and nasopharynx.

III. Post-treatment Disinfection/ Sterilization/ Waste Management Recommendations:

(i) *Surface disinfection:*

All sources [18,19,59-62] recommend implementation of strict surface disinfection protocol after every patient by complying with the respective national guidelines and regulatory health bodies.

Varied concentrations of sodium hypochlorite (NaClO) and other safer alternatives to chlorine-based bleach employed for 'two-step' terminal cleaning procedure and '2-in-1' clean approach are illustrated in Table 1. Also, 70-80% alcohol-based disinfectants (1-minute exposure time) are recommended for frequently touched surfaces, electronic equipment and surfaces sensitive to NaClO.

Evidence related to the efficacy of surface disinfectants against SARS-CoV-2:

An in vitro study by Chin et al. [63] demonstrated the susceptibility of SARS-CoV-2 to standard disinfection methods involving the use of household bleach (1:49 and 1:99), ethanol (70%), PVP-I (7.5%), chloroxylenol (0.05%), chlorhexidine (0.05%) and benzalkonium chloride (0.1%) for a minimum contact time of 5 minutes. Similarly, in vitro virucidal efficacy of formulated microbicidal actives and commonly used laboratory fixatives was recently documented [64, 65].

(ii) Fogging (*'no-touch surface disinfection' for terminal decontamination of large areas*):

The MoHFW [18] recommends "fogging" using a 20% working solution of commercially available 11% (w/v) hydrogen peroxide stabilized by 0.01% silver nitrate. The recommended volume of working solution required for fogging is approximately 1000 ml per 1000 cubic feet. However, the NHS [14] and DHA [62] do not recommend the use of fogging and fumigation in daily routine dental settings.

Evidence of efficacy of no-touch vapor-phase disinfection methods

The in vitro effectiveness of 35% condensing hydrogen peroxide vapor (20-minutes contact time) against transmissible coronavirus of pigs (a SARS-CoV surrogate) has been documented [66].

Hypochlorous acid (*HOCl):* HOCl offers the advantages of quick microbial disinfection in large clinical settings, and is relatively inexpensive, nontoxic and noncorrosive. Good safety profile, ease of on-site preparation, and stability of the prepared solution for up to 2 weeks when stored under ideal conditions make it a suitable choice for use as a disinfectant during fogging. The virucidal effects have been observed at a pH between 4.5 and 7 with concentrations above 50 ppm requiring at least 3 minutes of contact time and 10 minutes for more dilute solutions [67].

(iii) *Sterilization and disinfection of dental instruments and supplies:* Mechanical cleaning of instruments and photographic retractors using automated washer disinfectors has been strongly recommended to prevent transmission due to splashing during cleaning [68]. Heat-tolerant semi-critical items should be sterilized by autoclaving or by using dry heat. High-level chemical disinfection using 2% glutaraldehyde or 0.25% peracetic acid with shorter immersion times (12-90 minutes) is recommended for all heat-sensitive items [59].

(iv) *Time considerations for airborne contaminant removal following AGPs (fallow period):*

The recommended waiting time for neutral pressure single room requiring a minimum of 6 ACH is 1 hour, and that for negative pressure isolation room requiring a minimum of 12 ACH is 20 minutes with door closed [13, 30, 33]. The MoHFW [18] and NHS [14] recommend waiting time of 30 minutes and 10 minutes, respectively, for the aerosols/droplets to settle down before environmental cleaning.

(v) *Decontamination protocol regarding DHCP clothing in clinical environment:*

The NHS advises changing of clothes before going home, and ideally laundering them separately on site [60]. Hot-water laundry cycles at temperatures of at least 60°C, 71°C and 90°C have been respectively recommended by HTM01-05 (UK) [60], CDC [69] and ECDC [61]. Where textiles cannot undergo a hot wash, low-temperature laundry cycles based on the use of chlorine- or oxygen-activated bleach have been suggested. The CDC [69] advises the use of EPA-registered activated oxygen-based laundry detergents as an alternative to chlorine bleach to ensure fabric and color safety. It also indicates that regardless of whether hot or cold-water laundry cycles are employed for washing, the temperatures reached in drying and especially during ironing provide additional significant microbiocidal action.

(vi) Infected waste management:

Clinical waste from a confirmed or probable case is classified as category B (UN3291) waste [70] and should be segregated in double-layer yellow clinical waste bags (with a "gooseneck" knot). All sources recommend adhering to the appropriate healthcare facility policies and jurisdiction authority (Table 1) before disposal in a sanitary landfill.

IV. Establishing Communication, Training, and Information Systems:

While recognizing a good and clear mode of communication, workplace culture, management support, access to and trust in PPE, and a desire to deliver good patient care to be indispensable factors influencing healthcare workers' adherence to IPC guidelines [71], all sources emphasize on education and training to underpin efforts to integrate stringent IPC measures into healthcare practice.

(i) *Resources for remote consultations, communications, and staff support* - Different telehealth modalities that may be utilized include synchronous (involving real-time telephone or live audio-video interaction), asynchronous (non-real time communication through secure messaging) or remote patient monitoring (may or may not be in real time) [72].

It has been strongly recommended to review the latest advice from the indemnity organizations and adhere to the 'over-arching' principle regarding information sharing when considering remote working communications and virtual consultations [10,15].

DISCUSSION

Most of the guidelines have a consensus regarding implementation of rigorous administrative, engineering, and environmental infection control strategies. However, variations do exist with regard to the extent of incorporated details, use of respirators and air-borne precautions in non-AGPs settings, supplemental air-handling systems, and pre-operative mouthwashes. Varying epidemiological scenarios across the globe, variability in the extent of spread of outbreak, differences in the regional administrations, and substantial gaps in the evidence pertaining directly to the infectivity of SARS-CoV-2 in dental settings may explain variations among these international guidance sources. Most sources recommend the use of airborne precautions only during AGPs. However, considering the dynamic, evolving nature of this pandemic, the current absence of evidence regarding transmission risks during AGPs performed in non-AIIR dental settings cannot be construed as evidence of absence [73], and all patients with respiratory pathogens should be considered as potentially infectious. Also, recent reports [74-76] documenting isolated sporadic occurrences of re-infection underline the fact that both

healthcare workers and patients who have a prior SARS-CoV-2 infection may not always be protected against re-infection [75]. The unprecedented professional uncertainty and anxiety stemming from the highly fluid current situation runs the risk of sub-optimal dental practices. Anticipating increased patient volume and oral health needs in the immediate post-COVID period, this evidence-based review summarizing the key elements of guidance documents can serve as a useful resource tool for integration into contemporary dental practice.

Given the fact that the pandemic may be followed by post-pandemic resurgences as late as 2024 [77], dental healthcare teams need to refocus, retool, and reorganize themselves for effective resumption of evidence-based best practices. Strict adherence to guidelines on pre-appointment and administrative protocols, well-resourced PPE including face shields, implementing engineering control measures for droplet and aerosol removals in conjunction with high and low volume suction, and pre-procedural mouth rinses play an indispensable role in mitigating transmission risks in dental settings [42]. Recently, utilization of FDA-approved high molecular weight viscoelastic polymers such as polyacrylic acid and xanthan gum has been proposed for reducing or completely eliminating droplet formation by rotary and ultrasonic instruments, although its effectiveness and reliability remain to be tested [78]. Concerning patient and provider safety, it is also vital to strengthen communication, surveillance, and monitoring systems and further develop and utilize teledentistry as an indispensable tool [79].

Given the burden of oral disease and the possible far-reaching implications of oral health inequalities among socio-economically vulnerable populations, dental implementation strategies must be underpinned by equitable delivery of easily accessible, prevention-centric and sustainable oral health care [79]. From a public health policy perspective, the ongoing pandemic needs to be taken as a wake-up-call to proactively promote non-aerosolizing procedures and to integrate paradigm of preventive oral healthcare into primary medical healthcare settings [79].

CONCLUSION

To overcome the potential difficulties and challenges in resumption of elective dental care post-pandemic, dynamic restructuring based on the best available and continually evolving evidence is of paramount importance to mitigate professional anxiety while ensuring the safety of dental healthcare professionals and patients alike.

CONFLICT OF INTEREST STATEMENT

None declared.

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