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RELEVANT FACTORS FOR DENTAL CARE IN PLANNING THE RESPONSE AGAINST COVID-19 - A NARRATIVE REVIEW

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Trabalho apresentado à Universidade Fernando Pessoa
como parte dos requisitos para obtenção do grau de
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(Thadeu Laranja Aires)

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RESUMO

O objetivo principal deste trabalho foi analisar, através de uma revisão bibliográfica atual, como diferentes fatores se correlacionam para fundamentar as medidas implementadas pelas autoridades de saúde em resposta à corrente pandemia, no contexto de saúde oral.

A atual pandemia de COVID-19 causou já mais de 3 milhões de mortes, representando um desafio singular para a sociedade e os sistemas de saúde.

O papel dos médicos dentistas durante a pandemia é o de prover o tratamento dentário essencial e prevenir a transmissão do vírus, que possui características que podem aumentar o risco de transmissão cruzada no consultório, pelos aerossóis produzidos em inúmeros tratamentos dentários.

As Autoridades de saúde elaboraram protocolos para prevenir a contaminação cruzada do vírus em consultórios dentários, permitindo, assim, com a segurança devida e preventiva, que os pacientes continuem a receber tratamento dentário durante a pandemia.

Palavras-chave: pandemias, COVID-19, Medicina Dentária, controlo de infeção.

ABSTRACT

The main objective of this work was to analyze, through a review of current references, how different factors correlate to shape the response measures implemented by health authorities to the ongoing pandemic event, in the context of dental care.

The COVID-19 pandemic has claimed more than 3 million lives, presenting a special challenge for society and health care systems.

The role of dentists during a pandemic is to provide essential dental care while preventing transmission of the virus, which has some traits that can increase the risk of cross infection in dental offices, due to aerosols produced by many dental treatments.

Health authorities elaborated protocols to prevent the virus cross-contamination in dental offices, allowing patients to continue receiving dental care through the pandemic.

Keywords: pandemics; COVID-19; Dentistry; infection control.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS AND ABBREVIATIONS

COVID-19	Coronavirus disease 2019
WHO	World Health Organization
SARS-CoV-2	Severe acute respiratory syndrome coronavirus 2
EVD	Ebola virus disease
AIDS	Acquired immunodeficiency syndrome
RNA	Ribonucleic acid
CFR	Case-fatality ratio
IHR	International Health Regulation
ADA	American Dental Association
PPE	Personal protection equipment
USA	United States of America
EU	European Union
IFR	Infection-fatality ratio
VOC	Variants of concern
ECDC	European Centre for Disease Prevention and Control
DGS	Direção Geral de Saúde
CDC	Centers for Disease Control and Prevention
ICP	Infection control protocol
RAT	Rapid antigen test
SARS	Severe acute respiratory syndrome

I. INTRODUCTION

Even prior to 2019, pandemic preparedness was the subject of academic and public health authorities' interest, especially influenza pandemics. The ongoing COVID-19 (Coronavirus disease 2019) pandemic challenged that knowledge and society's pandemic response capacity in a way not seen for generations. These challenges were aggravated by the current context of globalization and dynamics of extreme mobility of people around the world, which facilitated global spread of the disease and required international coordination for the success of countermeasures by the World Health Organization (WHO).

This unique set of circumstances triggered innovation in the response to it, such as the development of vaccines in record times, but also the imposition of restrictions to personal mobility and freedom not seen before in modern western democracies out of wartime.

In the specific case of dental care, there was a big impact worldwide, with access to treatment being restricted, affecting both the population's oral health and the dental professionals' finances. The specificities of the SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2), the causing agent of COVID-19, make it so that the risks of cross-infection during dental procedures is particularly high. To counter that, health and dental care authorities around the world established novel procedures and protocols to minimize those risks and allow for continuity of essential dental care.

As a graduating Dentistry student, I have to deal with the uncertainty caused by rules constantly in flux, in the chaotic environment caused by a pandemic. And as a health care professional, it was especially hard to see patients whose oral health deteriorated after postponement of dental treatment, because of imposed restrictions or their fear of attending an appointment. On the other side, it was possible to understand that this is only one of the many aspects to be considered when implementing measures against COVID-19, and how complex these decisions can be. Academically, trying to understand the intricate relationship between epidemiological, public health - and dental care, in particular, economical, ethical, political and social factors that ultimately shape the different responses against this pandemic event is important to continuously improve these responses and the preparedness against future pandemic events.

The objective of this narrative review was to analyze the literature regarding pandemic preparedness and response, the specific characteristics of the SARS-CoV-2 and the COVID-19 pandemic event, and the countermeasures implemented in the context of dental care settings by national and international authorities.

MATERIALS AND METHODS

To achieve this, the search strategy spanned several thematic areas: pandemic preparedness, cross-infection dynamics in dental settings and ways to avoid it; the current COVID-19 event and its impacts in Dentistry; and response measures from different health authorities relevant to dental care.

The search included articles from the PubMed database, in English, with publication year posterior to 2000.

Further references from documentation from local and international health authorities, in English and Portuguese, and published books were also used.

Keywords: pandemic preparedness; pandemic response; COVID-19; Dentistry; infection control.

II. DEVELOPMENT

2.1 Pandemic preparedness

In order to improve pandemic preparedness and response, it is necessary to understand pathogen emergence, and anticipate the forms of microbial threats most likely to cause these events. This does not negate the need to also prepare for other types of pathogens (Adalja *et al.*, 2019).

Most newly-emerging diseases have a zoonotic origin (Taylor *et al., 2001;* Woolhouse *et al.*, 2005; Cleaveland *et al.,* 2007; Adalja *et al.*, 2019). According to the WHO, a zoonosis is any disease or infection that is naturally transmissible from vertebrate animals to humans (WHO, 2020a).

The dynamics of emergence of a zoonotic pathogen can be divided in three stages (Morse *et al.*, 2012), illustrated in Figure 1. In stage 1, pre-emergence, ecological disturbances can cause spillover of naturally occurring microbes to livestock or other non-human hosts. Stage 2, localized emergence, is when that spillover includes humans, either through small, self-limited events, or relatively large-scale events, which include human-to-human transmission limited to a few pathogen generations. An example is Ebola Virus Disease (EVD) outbreaks. In stage 3, indefinite human-to-human infection is established, and international spread leads to the emergence of a true pandemic (Morse *et al.*, 2012). Recent examples of this are the acquired immunodeficiency syndrome (AIDS) and COVID-19 pandemics.

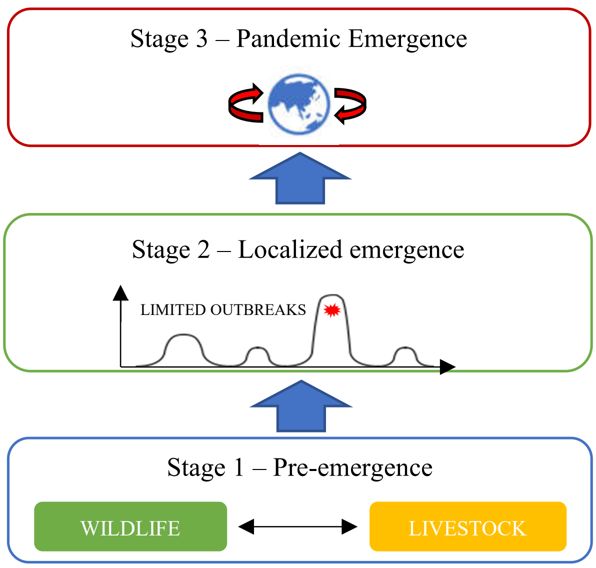

Fig. 1 - Stages of zoonotic pandemic emergence. (Adapted from Morse *et al.*, 2012)

Considering taxonomy, viruses cause a disproportionately high number of emerging diseases, in particular ribonucleic acid (RNA) viruses, due to their genetic instability and consequent higher chance of mutation resulting in more opportunities for them to become adapted to human hosts (Taylor *et al., 2001;* Woolhouse *et al.*, 2005; Cleaveland *et al.,* 2007; Morse *et al.*, 2012; Adalja *et al.*, 2019; Morens and Fauci, 2020).

Besides that, outbreaks caused by pathogens with a respiratory transmission route – aerosols or respiratory droplets, that are contagious during the incubation period, and to which most human hosts are immunologically naïve, are more likely to achieve a pandemic status (Adalja *et al.*, 2019).

Another factor to consider when planning for a pandemic event is the severity of the causing disease. COVID-19, for example, has a case-fatality ratio (CFR) of 2.14% WHOF Dashboard (WHO, 2021a). On the other side, Ebola virus disease kills an average of 50% of infected people, with some outbreaks having a CFR of up to 90% (WHO, 2021b).

Evidently, more aggressive methods of prevention and response must be used against pathogens with higher virulence. But a pandemic disease does not need to have a high mortality ratio to cause significant social disruption, as long as it can cause considerable morbidity (Adalja *et al.*, 2019). rate

Given that to reach Stage 3 (true pandemic) it is necessary that the pathogen spreads around the planet, international coordination is needed to prevent it. The global legal framework for pandemic preparedness was revised in 2005 and published by the WHO in 2008 as the International Health Regulations (IHR). The IHR purpose and scope are "to prevent, protect against, control and provide a public health response to the international spread of disease in ways that are commensurate with and restricted to public health risks, and which avoid unnecessary interference with international traffic and trade." (WHO, 2008).

Regarding health care systems, their roles in response to a pandemic event are: to provide adequate treatment for the disease, to accurately and timely diagnose cases of the pandemic infection, to keep providing essential health services during the event, to prevent transmission, to perform pharmacological intervention, such as vaccination, and to maintain laboratory capacity (Khan *et al.*, 2019).

Applying this reasoning to the field of Dentistry, dentists are required to provide essential dental care during pandemics, while also contributing to prevent transmission. According to the American Dental Association (ADA), essential dental care is defined as any care that prevents and eliminates infection, preserves the structure and function of teeth as well as the orofacial hard and soft tissues (ADA, 2020).

But given the occupational hazards inherent to dental practice, continuity of care and prevention of transmission can conflict with each other. In order to successfully balance them, and according to the IHR requirement of maintaining multisectoral national response plans, dental care authorities have response plans stating the specific measures to be taken in response to a pandemic, like adequate personal protection equipment (PPE) and its usage and procedural changes. Practical examples of these response measures applied to the COVID-19 pandemic are presented in section 2.3.

2.2 COVID-19 pandemic event

Starting on December 2019, cases of unexplained pneumonia were detected in Wuhan, China. Later, a coronavirus, now named SARS-CoV-2, was isolated and deemed responsible for the disease, designated COVID-19 (WHO, 2021c).

On March 11th 2020, Tedros Ghebreyesus, the General Director of the WHO, announced in a press conference that the current COVID-19 outbreak should be considered a pandemic (WHO, 2020b).

The WHO maintains a webpage with daily updates about COVID-19, and as of July 1st 2021 there are around 182 million confirmed cases worldwide, and 3.9 million confirmed deaths (WHO, 2021a).

The origin of SARS-CoV-2 is still unknown, but the WHO publicly states that the most likely possibility is that it originated from bats and jumped to human hosts through an unidentified intermediate host (WHO, 2021c). Several countries led by the United States of America (USA), as well as the European Union (EU), have raised concerns about these findings, and urged the WHO to further investigate the origins of SARS-CoV-2 (EU, 2021; US State Department, 2021). One of the concerns raised is that not enough effort was put to investigate alternative theories, such as a laboratory accident.

SARS-CoV-2 is a single-stranded RNA virus, transmitted directly by inhalation or mucosal contact with contaminated respiratory particles, or indirectly through contact with contaminated surfaces (WHO, 2021c). In general, older people and those with chronic conditions such as cardiovascular diseases, diabetes, respiratory diseases and cancer, are at increased risk of becoming severely ill with COVID-19 (WHO, 2021d). As noted before, the global CFR of COVID-19 is 2.14%. When including undetected cases of infection, the infection-fatality ratio (IFR) is obtained. Estimates of the IFR in different countries and regions vary between 0.14% to 2.7%, with the age composition of the respective location heavily influencing this variation (Ghisolfi *et al.*, 2020; Levin *et al.*, 2020; Meyerowitz-Katz and Merone, 2020; Seoane, 2021).

As stated previously, RNA viruses have high rates of mutability. With SARS-CoV-2, this means that many variants of the virus evolve, some of them with important traits, such as increased transmissibility or severity of the disease. Those are designated by the WHO as variants of concern (VOC). The table below is a summary of the characteristics of the VOC, as of June 3rd 2021.

Table 1 - SARS-CoV-2 VOC (adapted from European Centre for Disease Prevention and Control (ECDC), 2021)

WHO Label	**Lineage + Additional mutations**	**Country of first detection**	**Date of first detection**	**Evidence for impact on**		
				Transmissibility	**Immunity**	**Severity**
Alpha	B.1.1.7	United Kingdom	September 2020	Yes	No	Yes
	B.1.1.7 + E484K	United Kingdom	December 2020	Yes	Yes	Yes
Beta	B.1.351	South Africa	September 2020	Yes	Yes	Yes
Gamma	P.1	Brazil	December 2020	Yes	Yes	Yes
Delta	B.1.617.2	India	December 2020	Yes	Yes	?

In response to the pandemic, most countries imposed measures such as curfews and lockdowns, as well as travel restrictions. The severity of those measures evolved with a better understanding of the virus and varies from country to country, as well as the epidemiological situation.

Portugal, for example, has adopted a system in which certain criteria are evaluated in order to decide the restrictive measures applied to each municipality. The relevant epidemiologic parameters are the cumulative incidence of COVID-19 in the last 14 days and the change trend of the number of new cases, measured by the effective reproductive number (R(t)). The incidence and R(t) form the so-called risk matrix, updated by the General Health Administration (DGS, *Direção Geral da Saúde*). Listed as additional criteria are the response capability of the health care system and adequate testing capacity (Portuguese Council of Ministers, 2021).

Another response to the pandemic, in a global level, was the development and deployment of vaccines in record time. Individual countries have different policies and requirements regarding vaccine licensing. In an international level, as of June 16th 2021, the WHO issued recommendations for seven different vaccines - BioNTech/Pfizer, Astra Zeneca, Serum Institute of India, Janssen, Moderna, Sinopharm and Sinovac (WHO, 2021e).

Early data indicates that vaccination campaigns are being successful in reducing the likelihood of infection, severe illness and death by COVID-19 (Christie *et al.*, 2021; Haas *et al.*, 2021). One of the implications is that in partially vaccinated communities, older people prioritized in the early stages of vaccination acquired some degree of protection. Consequently, in some areas, younger people now represent a larger proportion of cases, hospital admissions and deaths than in the pre-vaccination period (Christie *et al.*, 2021).

But vaccine deployment has been uneven around the world. As of June 18th 2021, some countries, like Israel, have more than half of their populations fully vaccinated, while in low-income countries this rate is lower than 1% (Mathieu *et al.*, 2021).

To tackle this inequality, the WHO co-leads an initiative called COVAX. Its objective is "to accelerate the development and manufacture of COVID-19 vaccines, and to guarantee fair and equitable access for every country in the world" (WHO, 2021f). This program has the objective of securing 2 billion vaccine doses by the end of 2021.

2.3 Dentistry and COVID-19

According to the Centers for Disease Control and Prevention (CDC), pathogenic organisms can be transmitted in dental settings through direct contact with blood, oral fluids, or other patient materials; indirect contact with contaminated objects; contact of conjunctival, nasal, or oral mucosa with droplets containing microorganisms generated from an infected person and propelled a short distance; and inhalation of contaminated aerosols and airborne microorganisms that can remain suspended in the air for long periods (CDC, 2003). For the infection to occur through any of these routes, all of the following conditions must be present:

the pathogenic agent in sufficient numbers; a reservoir or source containing viable pathogens; a medium for transmission from this source to the host; an entry point to the host for the pathogen; and host immunological susceptibility (CDC, 2003). Therefore, to prevent cross-infection it is sufficient to eliminate any of the aforementioned conditions. Figure 2 illustrates these conditions for successful cross-infection in Dentistry.

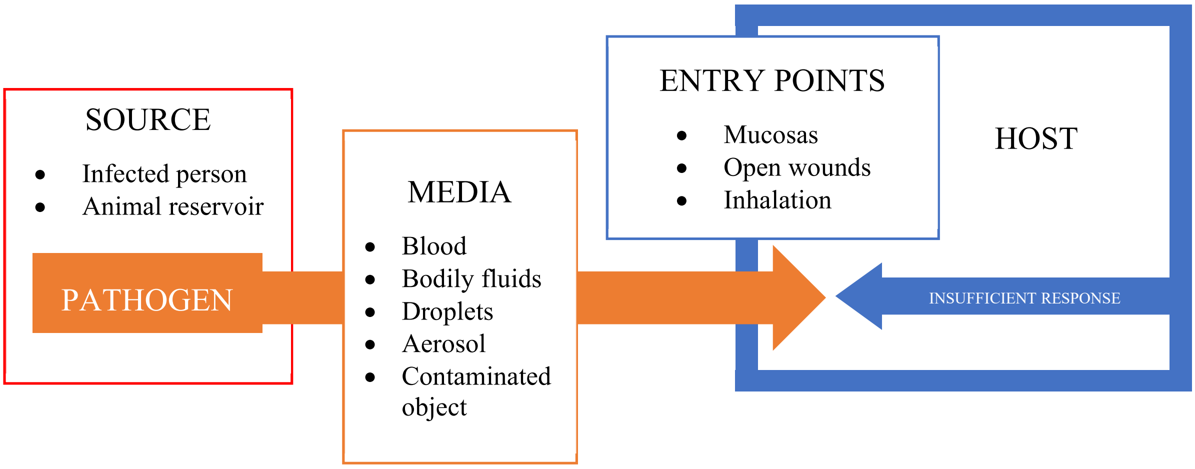

Fig. 2 – Routes and Conditions for Cross-Infection in Dental Settings (adapted from CDC, 2003)

Since performing dental care requires close proximity between professionals and patients, and the clinical procedures can produce respiratory droplets and aerosols, dental offices can potentially offer conditions for transmission of SARS-CoV-2 (DGS, 2020).

Before COVID-19, infection control protocols (ICP) in dental settings focused mainly on protecting against bloodborne pathogens. Therefore, with its emergence it became necessary to enforce adequate, stricter ICP against SARS-CoV-2, a respiratory virus, in order to provide at least essential dental care during the pandemic. Table 2 below shows examples of measures contained in some of the new ICP for dental offices recommended or enforced by several national and international health authorities.

Table 2 - Examples of COVID-19 ICP for dental offices (CDC, 2020; DGS, 2020; ECDC, 2020; WHO, 2020c)

Patients screening and access control	WHO	Identify and treat only patients who require urgent or emergency treatment. Identify patients with symptoms suggestive of COVID-19 Unaccompanied patients unless they require assistance
	ECDC	Consider postponing routine care Screen beforehand and at the facility to assess symptoms Unaccompanied patients unless assistance required
	DGS	No in-person treatment without previous remote contact Screen for COVID-19 symptoms and risk contacts. Patient helpers must stay at least 2m from the dental chair
	CDC	Consider postponing procedures Remote screening and at the facility to assess symptoms Teledentistry when available Limit patient supporters to those strictly necessary
Patients with confirmed or suspected COVID-19 infection	WHO	Only in urgency and emergency cases Referral to specialized oral health care centers Consider home treatment
	ECDC	Dedicated protocol, preferably referring to a designated dental care facility
	DGS	Only urgent cases, with the appointment at the end of the morning or afternoon
	CDC	Defer non-emergent cases Individual room, with closed door Consider scheduling patients for the end of the day
Staff and practice management	WHO	Training on the adequate procedures
	ECDC	Training on adequate procedures Regular hand hygiene Staff should be allowed to not attend work if presenting symptoms
	DGS	Contingency plan with tasks performed by each worker, and substitution options Training on adequate procedures and contingency plan
	CDC	Staff should stay home and receive no penalties when ill or under quarantine Screen staff and encourage self-monitoring for symptoms Job-specific and PPE training
General guidelines	WHO	Physical distancing (1m), regular hand hygiene and masks Staff with medical masks and preferably protected by a plastic or glass panel Posters with advice and instructions
	ECDC	Physical distancing (1.5m at least, and preferably only one patient waiting at a time), hand and respiratory hygiene and masks Staff protected by a plastic or glass panel, or using a face shield
	DGS	Educational posters Masks and hand hygiene No magazines or other objects handled by multiple people Prioritize contactless payment methods
	CDC	Physical distancing (6ft), facemasks and hand and respiratory hygiene Educational signs and posters No toys, magazines or similar objects that cannot be easily disinfected Staff protected by a plastic or glass panel

Treatments and procedures	WHO	Exposure only of materials necessary for the procedure Mouth rinse for patient (H_2O_2 or povidone iodine) Avoid using aerosol-generating procedures (AGP), and prioritize minimally invasive procedures and single-visit procedures. Performing AGP, use of four-handed dentistry, rubber dam and high-speed suction Avoid intraoral x-ray
	ECDC	Avoid AGP, using alternative non-aerosol-producing techniques if available If performing AGP, use of rubber dam and high-speed suction
	DGS	Avoid exposure of personal objects Door of treatment room closed Mouth rinse for patient (H_2O_2 or povidone iodine) Avoid AGP, and use high-suction aspiration and rubber dams Avoid intraoral x-ray
	CDC	Only materials used in the procedures exposed. All exposed objects and surfaces should be considered contaminated after the procedure Avoid AGP, prioritizing minimally invasive or atraumatic restorative techniques Performing AGP, use of four-handed dentistry, rubber dam and high-speed suction There is no evidence of the effectiveness of mouth rinsing against SARS-CoV-2
PPE	WHO	Gloves, fluid resistant disposable gown, eye protection and medical mask Fit-tested N95/FFP2 respirators or higher for AGP
	ECDC	An FFP2/3 respirator, eye protection, gloves and long-sleeve, water-resistant gown
	DGS	No accessories like rings or earrings, or nail polisher Low-risk: disposable apron, FFP2 respirator, face shield or goggles, gloves, cap and clinical shoes High-risk: disposable, fluid-resistant full gown with posterior opening, FFP2 or FFP3 respirator, face shield or goggles, gloves, cap, clinical shoes and shoe cover
	CDC	Low-risk areas, patients and procedures: surgical mask, eye protection, gown or protective clothing, and gloves High risk areas, procedures and/or patients: Fit-tested N95 or equivalent or higher-level respirator, gown, gloves, and eye protection
Environment	WHO	Clean and disinfect whole treatment area after every patient Ample natural ventilation, avoiding recirculating devices
	ECDC	Increased natural or mechanical ventilation Non-disposable equipment and frequently touched surfaces should be disinfected If an AGP was performed, the room needs to be ventilated before the next patient
	DGS	Adequate ventilation, preferably natural Clean, disinfect and renovate the air of the treatment area after every patient Clean and disinfect non-treatment areas every 1-2 hours
	CDC	Detailed instructions on ventilation practices Consider using ultra-violet germicidal irradiation Renovate the air of the whole treatment area after every patient. Only after that, perform cleaning and disinfection procedures

III. DISCUSSION

As stated before, the role of Dentistry during this pandemic is to continue to provide at least essential care while preventing transmission of COVID-19. The latter is achieved by eliminating one of the conditions in Figure 2. Hence, an effective response plan in dental settings takes into consideration those factors: the pathogen, SARS-CoV-2, and its intrinsic traits; the presence of an infected source in the dental office; an appropriate media for the transmission of the pathogen from the source to the host; a physical entry point to the host; and the host immunological response to the virus.

Considering the pathogen, SARS-CoV-2, the traits that it possesses that lead to it becoming a pandemic threat are well discussed in literature. In research about pandemic pathogens prior to 2020, there is a strong consensus regarding characteristics of pathogens most likely to cause a pandemic. Adalja *et al.* (2019) in particular affirm in a very comprehensive way that RNA viruses, with a respiratory route of transmission, capable of spread before the onset of symptoms, to which most humans are immunologically naïve (zoonotic or engineered), and with low but significant CFR are the most likely pathogens to cause a pandemic.

The high degree of concordance of these studies' findings between themselves and with the traits of the microorganism that ended up causing the current pandemic, SARS-CoV-2, seems to validate their conclusions. Accordingly, there is a strong scientific foundation on which to base the planning for the COVID-19 and even future pandemic events.

One aspect of SARS-CoV-2 emergence into a pandemic threat that is not well understood is its origin. Zoonotic or laboratory accident are the two main theories being publicly discussed. But this line of investigation is complicated by geopolitical factors, exemplified by the lack of high-quality, independent research on the matter more than 18 months since its estimated emergence in China. And since pandemics of this magnitude are rare, understanding its origins would offer unique and invaluable data for pandemics prevention programs on the early stages of disease emergence.

From a pathogen's spill-over event to the growth into a true pandemic, Morens *et al.* (2012) states several conditions that must be fulfilled, the last one of them being international spread. This suggests that the pre-2020 conditions of international mobility could have played an important role in COVID-19 spread, and that a last resort way to prevent a pandemic could be travel restriction. Indeed, research shows that in the early phases of the SARS-CoV-2, in what would correspond to the transition between stages 2 and 3 of the model presented by Morens *et al.* (2012), travel restrictions were imposed too late to effectively prevent a full pandemic, but were still able to delay its international spread (Chinazzi *et al.*, 2020; Linka *et al.*, 2020).

Another important characteristic of SARS-CoV-2 is its high rate of mutability, originating new variants. The relevance of this in the field of Dentistry is better understood in conjunction with the virus' interactions with a host, discussed further ahead.

The second condition for transmission of COVID-19 in dental settings is a source carrying SARS-CoV-2 into a clinic. It follows that the goal of response measures focused on this factor is to prevent someone infected or otherwise carrying, on contaminated hands for example, SARS-CoV-2 into the dental office.

Several procedures listed in Table 2 are aimed at reducing the chances of an infected person entering a dental clinic. One of them is reducing the number of patients altogether, by considering postponing routine treatment or even allowing only urgent and emergent cases to be treated. One plausible downside with this approach is the deterioration of oral health without early intervention, specially in situations that could be perceived by the patient as not urgent but could evolve into life-threatening situations, such as a pre-cancerous lesions. There is a need for further investigation in this area, but early research, including other types of cancer, points to a possible decrease of the number of detected malignant lesions during the pandemic (Coma *et al.*, 2021; Kempf *et al.*, 2021).

Another approach cited in Table 2 to prevent infected sources with SARS-CoV-2 in dental clinics is the screening and triage of patients, both remotely or on arrival at the facility, for symptoms like fever and coughing. But, since COVID-19 can be asymptomatic, or be transmitted before the onset of symptoms, there are patients infected with the virus that will not be identified with this procedure. A plausible addition to make this triage more robust would be considering the usage of rapid antigen tests (RAT). In Portugal for example, at the time of this writing, RAT are widely available for purchase, with $\geq$ 90% sensitivity and $\geq$ 97% specificity (European Commission Directorate-General for Health and Food Safety, 2021).

Other measures in the ICP to control the access of sources of SARS-CoV-2 to dental facilities are the restriction on patients' companions and the enforcement of hand hygiene with alcohol on arrival, to prevent indirect transmission through contaminated hands. One notable absence in the ICP examined in Table 2 was the absence of clear recommendation for staff screening, with exception of the CDC.

The third condition in Figure 2 for transmission of a disease in dental care is a suitable medium of transport from the source to the host. As stated in item 2.2, COVID-19 is transmitted by respiratory particles and contact with contaminated surfaces. In the case of Dentistry, this has particular importance since many common procedures, such as the use of high-speed hand pieces and ultra-sounds, generate splatter and aerosol, potentially facilitating the spread of the virus. Thus, many of the items in the ICP listed are aimed to counteract this factor, such as limiting the usage of AGP and applying special precautions when they are indispensable, cleaning and disinfection of exposed areas in the treatment room between patients, proper ventilation, and others. Those measures either prevent the air and surfaces from getting contaminated or renovate and clean them in case of contamination.

Of notice is the recommendation to use alternative treatments to AGP, because on one side, it would reduce the number of procedures considered to be high-risk; on the other, it would require knowledge and technical capability on the part of the dentist to perform them. Since these treatments were not considered the standard ones prior to COVID-19, it is likely that most dentists are not proficient with their use, requiring their inclusion and emphasis in basic formation and continuous professional education programs. Thus, this would be a measure implemented for the long-term, to counteract both an eventual establishment of SARS-CoV-2 as an endemic virus and future outbreaks of airborne agents.

The fourth condition for disease transmission in dental practices is host entry point. As said previously, SARS-CoV-2 enters the host through inhalation or mucosal contact with contaminated particles. This access can be counteracted using proper PPE, especially mucosal and respiratory. In this regard, there were slight differences between the exemplified ICP as to what types of situations constitute high or low risks, and respective PPE. When considering high-risk procedures, though, the recommended PPE is very similar, with all of them including water-resistant gown, gloves, FFP2/N95 respirator and eye protection. One subtle but important difference is that the WHO and CDC require that respirators must be fit-tested.

There is evidence that fit-testing provides less leaks than simple use of FFP2 respirators, but not that it actually increases the protection offered against SARS-CoV-2 (Regli *et al.,* 2021). In fact, in a systematic review by Verbeek *et al.* (2020) it is shown that, in the SARS (severe acute respiratory syndrome) outbreak, the most important protective factor was consistency in PPE usage, rather than specific type of PPE.

The last condition in Figure 2, and the last line of defense against successful transmission of SARS-CoV-2 from a source to a host, is the host immunological response. An effective response from the adaptive immune system demands a previous interaction with the antigen, either through previous infection or vaccination (Kindt *et al.*, 2007). Thus, the importance of including dental care professionals in priority groups for vaccination as it is a controllable way of consistently affecting this condition for transmission in a dental care setting, and providing continuity of dental care.

But vaccines are not 100% effective in preventing infection (Kindt *et al.*, 2007), and cases of COVID-19 recurrence are reported, some of them being reinfections, proven through genome sequencing (To *et al.*, 2020; Van Elslande *et al.*, 2020; Piri *et al.*, 2021). So, even after patients and dental care professionals have developed some degree of immunity, through vaccination or previous COVID-19 infection, the implementation of other protection measures should continue.

Complicating the matters is the high rate of mutations in SARS-CoV-2, that leads to the evolution of many variants, and as shown before, some of them are VOC due to increased transmissibility or severity of the disease. Some of these VOC, shown in Table 1, have impact on immunity, being less prone to neutralization by convalescent plasma, for example (ECDC, 2021). But, at this time, there are not good evidences that the identified VOC impact the current vaccines efficacy in preventing severe disease (Krause *et al.*, 2021).

This could change if the vaccination inequalities referred in item 2.3 are allowed to continue, because leaving developing countries unprotected by vaccination could spur the evolution of variants with the potential to render the current vaccines obsolete. For this reason, the Director-General of WHO, Tedros Ghebreyesus (2021), argues that vaccine nationalism is morally unacceptable and epidemiologically self-defeating for everyone, because “A hermetic seal between the world’s haves and have nots is neither desirable nor possible”.

Finally, even though the current literature on COVID-19 is understandably evolving on a daily basis, the understanding of different health authorities as to what factors are relevant in the response against COVID-19 in dental settings, and the ways to address those factors, is remarkably similar, and well supported by existing literature.

IV. CONCLUSIONS

SARS-CoV-2 has many of the traits of pathogens most likely to cause a pandemic that were consistently identified by pre-2020 research. There is solid scientific foundation on which to plan for the current and future pandemics, and knowledge about the virus evolves at a fast pace. But independent research about its origin is lacking, and due to geopolitical factors, it is likely to stay this way.

There are several factors that makes controlling the pandemic harder, such as the virus high transmissibility and mutability, combined with high levels of international mobility in modern society. To face them, responses such as travel limitations and extremely fast development of efficient vaccines were implemented. So far, current vaccines are still effective against VOC, but inequalities in its deployment must be addressed to avoid mutations of the virus that render these vaccines ineffective.

Some aspects of dental health were affected by the pandemic, such as oral cancer detection, and research about it is ongoing. Health authorities implemented comprehensive ICP to control transmission of SARS-CoV-2 in dental offices. These protocols are similar to each other, and address effectively the different conditions for COVID-19 cross-infection through access control and screening, adequate use of PPE, hand and respiratory hygiene, social distancing, treatment protocol changes and environmental cleaning and disinfection. This allows continuity of dental care during the pandemic while controlling transmission.

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