

Climatization systems for Brazilian dental teaching clinics: a narrative review in the context of the COVID-19 pandemic

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ABSTRACT

COVID-19 outbreak has reaffirmed the need to maintain ventilation of dental environments properly. This study was carried out to encourage a reflective analysis of the risks of air contamination in Brazilian dental clinics. A narrative review of the literature was carried out on the recommendations of heating, ventilation and air conditioning (HVAC) systems in dental environments, considering the risks of air contamination in Brazilian dental teaching clinics. The literature research was conducted in the PubMed and Google Scholar databases and the main studies that evaluated the climatization systems and portable high efficiency particulate air filtration (HEPA) units in dental environments were included. Furthermore, it were analyzed the guidelines of the Centers for Disease Control and Prevention, the Brazilian National Health Surveillance Agency, the Brazilian Ministry of Health and important institutions of the different countries. After the initial research, a review of the guidelines and articles that assess the use of HEPA units to improve air cleanliness. This analysis was done by different groups of researchers. All documents mentioned that the air quality of the dental offices must follow the protocols in current legislation to ensure the safety of the environs. They reaffirmed that the COVID-19 pandemic makes it imperative that dental environments equipped with air conditioning have mechanical air renewal devices. An alternative for Brazilian dental teaching clinics equipped with mini-splits or window air conditioning could be the installation of exhaust fans and portable HEPA filter units to exchange air and reduce aerosols inside the environments.

Descriptors: Air Purifier. COVID-19. HEPA Filters. HVAC Systems. Dental Schools.

1 INTRODUCTION

In December 2019, there was an outbreak of pneumonia in Wuhan, Hubei Province, China. The new pneumonia was related to a severe acute respiratory syndrome caused by a newly coronavirus, the SARS-CoV-2¹. This virus generated a global health crisis, and its rapid spread culminated in the COVID-19 pandemic, affecting all levels of society.

COVID-19 had a major impact on the area of education. In April 2020, the vast majority of universities closed in 175 countries with 200 million students affected². Brazil had, at that time, 350 institutions offering dentistry as a formal degree to over 125,585 students who suffered losses in the learning process³.

Given this scenario, infection control measures have become even more necessary. Dentists are among health professionals with a higher risk of contamination by SARS-CoV-2 since constant exposure to aerosols are generated during clinical care^{4,5}. The high risk of contamination during clinical practice is challenge to the return and maintenance of activities in teaching clinics⁵⁻⁸.

At the beginning of the COVID-19 crisis, the Centers for Disease Control and Prevention (CDC) published guidelines for dental care during the pandemic, emphasizing the importance of proper maintenance of ventilation systems in dental clinics⁹. The air conditioning and air renewal designs are essential to ensure indoor air quality. Therefore they are regulated worldwide, being standardized in Brazil by the technical regulation NBR16401-3¹⁰.

However, in Brazil, dental teaching clinics are ordinarily equipped with air conditioners without mechanical renovation or air cleaning^{11,12}. In many places, air conditioning systems have a renewal of air only through the slits in doors, windows, and the entry and exit of people. Therefore, these environments are

configured as an additional risk factor for transmitting infectious diseases in contaminated environments¹³.

In this context, this study performed a narrative review based on main studies and guidelines published by Brazilian and international regulatory bodies regarding the heating, ventilation, and air conditioning (HVAC) systems in dental environments, to provide a reflective analysis on the risks of air contamination in Brazilian dental teaching clinics. It also evaluated the indications for the use of portable high-efficiency particulate air (HEPA) filtration units, as an alternative to improve the cleanliness of the ambient air.

2 METHODS

To undertake the narrative review, literature research was conducted in the PubMed and Google Scholar databases. The search strategy used the keywords “Air purifier AND COVID-19 AND Dental Schools OR Dentistry OR Dental Practice”. It were included the main studies published in English during 2020-2021, that evaluated the climatization systems and portable HEPA filter units in dental environments. We also included some studies published in Portuguese that reported specific information about teaching clinic environments of Brazilian Dental Colleges. Another approach was also taken, which consisted of analyzing the guidelines of the CDC, the Brazilian National Health Surveillance Agency (ANVISA), the Brazilian Ministry of Health (BMOH), and some Brazilian and international institutions¹⁴⁻²¹. Documents published in Portuguese, Spanish and English were included. Our research team consisted of two PhD researchers with formal training in qualitative methods and three graduate students in dentistry with informal training in the same methods.

The guidelines analysis was based on the

methods and techniques of content analysis proposed by Bardin²². We worked in pairs to review all sources and code the presence or absence of interest topics in a given source. The data were systematized as follows: 1) initial reading of the documents, to obtain a global view of them; 2) selective reading to identify the useful information to this study, highlighting the recommendations regarding the air conditioning and air purifiers in dental environments; and 3) categorization and grouping of the sections by the similarity between them and 4) descriptive and reflective analysis of the data.

3 RESULTS

Recommendations on heating, ventilation, and air conditioning (HVAC) systems of the dental environments

After the selective reading of the documents published by CDC, ANVISA and the BMOH, the main information regarding the air conditioners and HEPA filters of the dental environments and their respective recommendations during the COVID-19 pandemic were categorized and summarized, as shown in table 1.

All documents mentioned that the air quality of the dental offices must follow the protocols in current legislation to ensure the safety of the environs. They reported the importance of the dental environments having air conditioning systems equipped to exhaust fans that guarantee air exchanges and due to the increased risk of contamination, aerosol-generating procedures (AGPs) should ideally occur in a respiratory isolation unit with a HEPA filter. As an additional protective measure, the use of portable HEPA filter units during and immediately following AGPs is also recommended.

The documents published by ANVISA and

the BMOH suggest that if there is no respiratory isolation unit, one should use air conditioning systems with the exhaust or leave the windows open to guarantee air renewal in the environments^{4,23}.

HVAC systems

The CDC guidelines, published in 2003, reported that to prevent the dissemination of airborne infectious diseases it is critical that healthcare facilities be equipped with HVAC systems designed to maintain a comfortable indoor temperature, while guaranteeing the removal and filtration of contaminated air. Filtration is the main means of cleaning the air, given that HEPA filters have 99.97% efficiency in removing particles $\geq 0.3 \mu\text{m}$ in diameter²⁵. In 2020, the CDC guidance for dental settings during the COVID-19 pandemic ratified these guidelines and emphasized a need to optimize the use of engineering controls for proper maintenance of HVAC systems⁹.

Portable HEPA filter units

Portable HEPA filters are used to temporarily filter and recirculate the air in rooms without general ventilation, reduce aerosol concentrations and increase the filtering capacity of systems that do not provide adequate airflow. They should be capable of recirculating all or nearly all of the room air through the filters, and the unit should be designed to achieve the equivalent of ≥ 12 air changes per hour (ACH)²⁵.

In 2006, the BMOH and ANVISA reported that to minimize the risk of airborne transmission, it is necessary to maintain a ventilated environment. During dental AGPs, the use of exhaust fans with HEPA filters is indicated. They also recommend that the dental care establishments, with air conditioning systems, must ensure adequate design through specialized professionals and follow the specifications

Table 1. Recommendations about heating, ventilation and air conditioning (HVAC) systems and portable HEPA filtration units during the COVID-19 pandemic

DOCUMENT	SOURCE / YEAR	MAIN RECOMMENDATIONS ON CLIMATIZATION SYSTEMS IN DENTAL ENVIRONMENTS
Guidance for Dental Settings - Interim Infection Prevention and Control Guidance for Dental Settings During the Coronavirus Disease 2019 (COVID-19) Pandemic.	Center for Disease Control and Prevention (CDC), 2020 ⁹	<ul style="list-style-type: none"> - Aerosol generating procedures (AGP) should ideally take place in an airborne infection isolation room, equipped at negative pressure relative to the surrounding areas, and with a minimum of 6 air changes per hour (ACH). Also, 12 ACH are recommended for new construction or renovation. - Consider the use of a portable high-efficiency particulate air filtration (HEPA) filter unit while the patient is undergoing, and immediately following, an AGP. - The portable HEPA unit to reduce aerosol concentrations in the room and increase the effectiveness of the turnover time.
Technical Note N° 04/2020 – 02/25/2021 GVIMS/GGTES/ANVISA. Guidelines for Health Services: Prevention and Control Measures that must be Adopted During Assistance to Suspected or Confirmed Cases of Infection by the New Coronavirus (SARS-CoV-2).	Brazil, 2020 ²³	<ul style="list-style-type: none"> - The dental AGPs should be performed, preferably in a respiratory isolation unit with negative pressure and HEPA filters. - Use air conditioning systems equipped to exhaust fans that guarantee air exchanges or keep the windows open during service, ensuring air renewal in the dental environments.
Guide of orientations for Dental Care in the Context of COVID-19	Brazil, Ministry of Health; 2020 ⁴	<ul style="list-style-type: none"> - As a precautionary measure for contamination of aerosols, the PGAs should be performed preferentially in a health unit with a HEPA filter. - When the health unit does not have an area with negative pressure respiratory insulation and a HEPA filter, it is recommended to use an air conditioning system with exhaust and or to keep the windows open to guarantee air renewal in the environments.
Technical Note N° 173/2020 SEI/GRECS/GGTES/DIRE1/ANVISA. Clarifications to the Regional Council of Dentistry of the State of São Paulo about the reopening of Dental clinics.	Brazil, 2020 ²⁴	<p>Collective dental offices:</p> <ul style="list-style-type: none"> - During AGPs, measures and devices that promote air circulation and renewal or the reduction of suspended particles should be adopted. Engineering measures must be designed by qualified professionals, besides being under current legislation and using devices that are registered in ANVISA.

of the Brazilian Association of Technical Standards (ABNT). Ideally, air conditioning installations should be central for comfort and ambient air treatment, besides providing a minimum outdoor airflow of 6 (m³/h)/m² and a minimum total airflow of 18 (m³/h)/m². The ambient temperature must be maintained between 21°C and 24°C, and the relative humidity between 40% and 60%²⁶.

Moreover, ANVISA reported that window air conditioning and mini-split air conditioners do not promote the renovation of the air environment. Therefore, they are not capable of maintaining good ambient air quality in dental care facilities. These apparatuses can only be

installed in dental services if accompanied by ventilation or exhaust systems to ensure the renewal of indoor air²⁴.

After the global crisis of COVID-19, ANVISA published technical note N° 173 in June 2020 to give directions about the importance of adopting devices that promote air circulation or the reduction of suspended particles²⁴.

Recommendations on air renovation during the COVID-19 outbreak

Given the pandemic scenario of COVID-19, Brazilian and international institutions published recommendations regarding air renovation in care environments, as shown in table 2.

Table 2. Recommendations of Brazilian and international institutions regarding air renovation in dental clinics

INSTITUTION/ YEAR	DOCUMENT	MAIN RECOMMENDATIONS ON CLIMATIZATION SYSTEMS IN DENTAL ENVIRONMENTS
Dentist Advice. Collegiate Organization of Dentists of Spain, 2020 ¹⁴ .	Strategic Action Plan for the Covid-19 Containment Period.	Comparing the different air purification systems, the best method seems to be air filtering using negative pressure or high pressure, together with high-efficiency particulate air filtration (HEPA) filters.
Office of Chief Dental Officer England, 2020 ¹⁵ .	Standard Operating Procedure Transition to Recovery - A phased transition for dental practices towards the resumption of the full range of dental provision.	<ul style="list-style-type: none"> - The dental surgeries must be performed in neutral pressure rooms. - Windows in neutral pressure rooms should be opened, or extractor fans that vent to the exterior should be used. - Fixed air conditioning units and portable air conditioning, which do not recirculate to other rooms, can be used.
South African Dental Association (SADA, 2020) ¹⁶ .	SADA Dental Protocol in Response to the COVID-19 Pandemic.	<ul style="list-style-type: none"> - Ventilation can be natural (windows) or artificial (a closed or open system). However, if any circulation occurs, this air must pass through an appropriate HEPA filter (H13/14) capable of removing particles of less than 0.1 µm, as the coronavirus is 0.15 µm in size-in the system. - The ideal scenario for performing aerosol generating procedures (AGPs) is a negative pressure ventilated space with a minimum of 12 air changes per hour (ACH) using an external exhaust connection.
Brazilian Dental Education Association (ABENO, 2020) ¹⁷ .	ABENO Consensus: Biosafety in Dentistry Teaching Post-pandemic of the COVID-19.	<ul style="list-style-type: none"> - The use of portable HEPA filtration units should be considered during and immediately after an AGP. The use of these filtration units reduces the particle count of the environment and decreases the time for air filtration, as it does not depend only on the capacity of the building's heating, ventilation and air conditioning (HVAC) system.
Brazilian Intensive Care Medicine Association (AMIB) & Brazilian Federal Council of Dentistry (CFO, 2020) ¹⁸ .	AMIB/CFO recommendations for the dental care COVID- 19: AMIB / CFO Dentistry Committee of confronting the COVID-19.	<ul style="list-style-type: none"> - The AGPs should be performed, preferably, in a respiratory isolation unit with negative pressure and HEPA filters. In the absence of this air filtration unit, the patient should be placed in a room with closed doors and open windows, restricting the number of professionals during care.
American Dental Association (ADA,2020) ¹⁹ .	Occupational Safety and Health Administration (OSHA) Guidance Summary: Dentistry Workers and Employers.	<ul style="list-style-type: none"> - Recommends the use of local exhaust ventilation to capture and remove aerosols generated during treatment, and the use of directional airflow to remove workplace hazards. - Use high evacuation suction and dental dams to minimize droplet splatter and aerosols.
Superior Council of Dentistry Faculty of the province of Buenos Aires (COSUCOBA, 2021 - Argentina) ²⁰ .	Recommendations Oriented to Dental Practice in a Health Emergency Situation due to COVID-19.	<ul style="list-style-type: none"> - Use of natural ventilation is recommended under airflow conditions and acceptable climatic conditions (for evaluation of natural ventilation, consultation with an expert is suggested). Its use raises a waiting time between patients and depends on the type of procedure performed: <ul style="list-style-type: none"> • 1 to 3 hours for AGP; • 15 minutes or 30 minutes for non-AGP. - Mechanical ventilation under negative pressure and air filtration are recommended for variable or insufficient air exchange flow rates (natural ventilation) and/or adverse weather conditions.
Royal College of Dental Surgeons of Ontario (2021, Canada) ²¹ .	COVID-19: Managing Infection Risks During In-Person Dental Care.	<ul style="list-style-type: none"> - Consulting an HVAC professional to determine whether changes to the HVAC system can improve ACH for the dental practice. - If changes to the HVAC system are not possible, dentists may consider using an air cleaner, fixed or portable (e.g. HEPA filter), to increase the ACH for a specific operatory room.

The importance of keeping the natural or artificial ventilation of dental offices to avoid airborne infections was reported. Further, the use of HEPA filters to minimize cross-contamination through aerosols was indicated.

WHO (2021) recommends that air purifiers be fixed into HVAC systems. Although, the additional installation of HEPA filter units (ceiling-mounted or portable) effectively reduces aerosols present in the environment. This organization also recommends using HEPA air filter classes H10 to H14, warning about the importance of cleaning and maintaining the filters, as their performance decreases due to the filter load²⁷. Conversely, HEPA filters (H13/14) may be more appropriate since they are capable of removing particles of less than 0.1 μm , being more efficient for coronavirus, which is 0.15 μm in size¹⁶.

Therefore, an HVAC specialist should be consulted by the clinic supervisor in order to obtain information about the air filter system of the dental clinic. Popular air filter systems, which are commercially available, such as air purifiers, air cleaners, etc., and even standard HEPA filters may only remove particles up to 0.3 μm , which can be unsuitable for isolating and killing the SARS-CoV-2¹⁶.

The clearance rate of aerosols in an enclosed space is dependent on the extent of mechanical or natural ventilation, and the size of the droplets created. The greater the number of ACH, the faster aerosol will be cleared. As a guide, in a single room with 6 ACH, 60 minutes post-AGP downtime is recommended. For a single room with 10-12 ACH, 20 minutes post-AGP downtime is recommended¹⁵.

However, if dentists do not know the rate of air changes of the office, they must assume a rate of 2 ACH and adhere to a minimum fallow time of 3 hours. Therefore, it is essential to ensure that the operating environment remains

empty for a length of time that achieves 99.9% removal of airborne contaminants²¹.

Indications of the literature over the dental education during the COVID-19 pandemic

Worldwide, most dental schools suspended teaching activities due to the COVID-19 pandemic abruptly changing academic calendars, delaying graduation ceremonies and entry of new students²⁸.

Given this scenario, the managers of Brazilian dental schools must keep minimizing the contamination risk of SARS-CoV-2 by adopting environmental and air hygiene practices.

SARS-CoV-2 is primarily transmitted from an infected person via respiratory droplets, aerosols, or close personal contact. Transmission may also occur through fomites by contact with surfaces or objects used on or by infected people¹.

CDC and WHO emphasize that frequent disinfection of surfaces and objects touched by people is important. However, they recognize there is limited evidence regarding coronavirus transmission through on contaminated surfaces²⁹.

There is a lack of clarity about the risks of fomites, in comparison to the much bigger risk posed by transmission through the air. People and organizations continue to prioritize costly disinfection efforts, when they could be putting more resources into emphasizing the importance of masks, and investigating measures to improve ventilation. Therefore, the efforts to prevent spread should focus on improving ventilation or installing rigorously tested air purifiers²⁹.

During the COVID-19 outbreak, several published studies evaluated the climatization systems and portable HEPA filter units in dental environments, as shown in table 3.

The aerosol transmission could contribute considerably to becoming infected with SARS-CoV-2 during a prolonged stay in crowded, poorly ventilated indoor settings (meaning transmission

could occur at a distance > 2 m)³⁴. The aerosols generated remain at elevated levels around the dental team during AGPs³³. Thus, it is crucial to reinforce the biosafety protocols and make individual and collective risk analyses to reorganize dental services⁴.

Table 3. Some of the main papers that reported indications over the climatization systems and portable high-efficiency particulate air filtration (HEPA) filter unit during the COVID-19 pandemic

AUTHORS / YEAR	COUNTRY	METHOD	MAIN OUTCOMES
Ren et al. (2021) ³⁰ .	USA	It was evaluated the effectiveness, isolated or combined, of mechanical ventilation systems and portable air cleaner (PAP) with a high-efficiency particulate air filtration (HEPA) filter, for remove aerosols. Analysis was made after 5 and 30 minutes of the generation of aerosols caused by the burning of incense.	<ul style="list-style-type: none"> - The PAPs with HEPA filters reduced ten times the aerosol particle concentrations of 0.3 µm. - After 30 min, the association of mechanical ventilation with PAP reduced the accumulation of aerosols. Also, it promoted a significant increase in the removal of particles compared to environments with mechanical ventilation only. - The use of PAP with HEPA filter improves aerosol removal in rooms with reduced ventilation.
Sarapultseva et al. (2021) ³¹ .	Russia	Retrospective cohort study with 157 health care workers (HCWs) from 3 dental clinics in Ekaterinburg (Russian Federation), during the coronavirus disease pandemic. Clinics A and B were equipped with a V6000 aspirating system with a vacuum controller (dry or semidry mode) and HEPA filters. Clinic C was equipped with VS900 aspirating vacuum pump without HEPA filters. All the HCWs underwent serological testing once a week to detect immunoglobulin G and M antibodies against the SARS-CoV-2.	<ul style="list-style-type: none"> - The prevalence of SARS-CoV-2 infection positive was significantly higher at clinic C (equipped with an aspirating vacuum pump without HEPA filters) than at other clinics. - The type of aspirating system used and the presence of HEPA filters could affect the prevalence of SARS-CoV-2 infection across dental clinics. Therefore, it recommended using aspirating systems installed with HEPA filters, which evacuate and dissipate aerosols into specialized areas.
Yang et al. (2021) ³² .	USA	Pilot study conducted in a dental unit of the dental school, Temple University (USA). Dental procedures simulation was conducted using high-speed handpiece (HSH) or ultrasonic scalers (US) to generate dental aerosols. It was performed measurements of particles distribution, in the ambient air surrounding the dental chair. The measurements were obtained before and after dental procedures simulation to evaluate the effectiveness of aerosol control using high-speed suction (HSS) + saliva ejector (SE) with or without extraoral high volume suction systems (HVS). The HVS unit had a motor-driven high-power suction, and contained HEPA filtration system and a medical-grade UV-C light disinfectant system.	<ul style="list-style-type: none"> - Four locations were identified with elevated aerosol levels, including the chest of the dentist, the chest of the patient, the chest of assistant, and three feet above the patient. - The increase of aerosol level was minimal during dental procedures when using SE and HSS. The use of HVS further reduced aerosol levels to below baseline level. - Due to these outcomes, the Temple University granted permission to the dental school to resume its clinical operations under strict and using PPE conditions. After six months, there have been no cases of COVID-19 that are linked to dental care.
Ehtezazi et al. 2021 ³³ .	United Kingdom	It was evaluated the characteristics of the aerosols generated by standard dental procedures. It also investigated the effectiveness of different combinations of aerosol-management interventions. A sequence of six aerosol generating procedures (AGPs) was performed on a phantom head to assess the effectiveness of four combinations of interventions based on low-volume suction (LVS), high-volume intraoral suction (HVS [IO]), high-volume extraoral suction (HVS [EO]), and an air cleaning systems (ACS, contain HEPA filters to purify and recirculate room air). Real-time aerosol measurements were acquired from six locations within a typical dental treatment room (35 m ³).	<ul style="list-style-type: none"> - Dental AGPs produce aerosols characterized by particles <0.3 µm in diameter. Aerosol-removal interventions such as HVS (IO) alone or in combination with an ACS may rapidly reduce particle concentrations to within background range. - HVS combined with the ACS was enough to reduce the fallow time to zero minutes and to control the median and range of the aerosol particle dose at all areas in the surgery. The ACS used in these experiments was set to deliver 24 ACP in a 35 m³ surgery. - In the absence of ventilation within a modest-sized (35 m³) surgery, particles associated with dental AGPs may persist for approximately half an hour.

4 DISCUSSION

The CDC guidelines were one of the main information sources analyzed in this study, because this agency has provided recommendations to prevent health-related diseases and infection control since 1970. Its guidelines are constantly updated and based on scientific evidence recognized worldwide to offer safety information for health facilities.

The guidelines and regulations published by ANVISA and the BMOH were also analyzed, because these bodies are responsible for regulating and guiding the health services of Brazil.

The results of our study showed that aerosol control is the main challenge of dentistry to reduce the risk of infectious transmission between dental professionals and patients. The contamination can be greater in dental teaching clinics due to the high number of occupants and procedures performed simultaneously. Also, dental care involves close patient contact for prolonged periods raising the risks of transmission through aerosol generation during dental procedures.

Thus, it is crucial to guarantee natural or artificial ventilation of dental offices to avoid SARS-CoV-2 infections. However, natural ventilation can have insufficient or variable flow, depending on the climatic conditions, and the number, size, and location of the openings. Therefore, to consider this approach, an expert must evaluate the system's effectiveness²⁰. Moreover, Brazil has a diverse climate that is characterized by high temperatures in almost the entire territory. The use of personal protective equipment (PPE) associated with high temperature, hinders dental care in places without air conditioning and may create unhealthy conditions for dental healthcare personnel (DHCP) and patients.

On the other hand, there are reports about irregularities in Brazilian dental teaching clinics,

whose air conditioning systems do not have air circulation, renovation and filtration, configured in environments contaminated by infectious agents suspended in the air^{11,12}. Thus, it is essential to reassess the climatization systems of Brazilian dental teaching clinics to make adaptations that guarantee the safety of these environments.

However, the scarcity of resources and funds for Brazilian Universities are an obstacle to major architectural projects, such as the installation of central air conditioner systems. Thus, the use of exhaust fans that guarantee the necessary air changes and the purchase of portable HEPA filter units can be an efficient and cheaper alternative for reducing aerosols in dental teaching environments.

In this scenario, dentistry schools, regulatory boards, scientific associations and public government authorities must join efforts to implement lasting responses to the challenges posed by prolonged viral epidemics¹. An essential measure is to guarantee and encourage vaccination of the population, as vaccines play a crucial role in limiting the spread of coronavirus.

At beginning of March 2022, about 81% of the adult population of Brazil was fully vaccinated against COVID-19³⁵. Along with the advance of vaccination, Brazilian dental schools are reopening in a gradual manner and adopting distance education in a hybrid-teaching format²⁸.

Although the percentage of vaccination coverage in Brazil is growing, the pandemic control is unequal and remains a challenge. The vaccines are not available to people of all countries in the world, which can contribute to the development of other SARS-CoV-2 variants and the loss of effectiveness of the vaccines.

At November 2021, the Omicron variant has emerged as being highly contagious, leading to increased transmissibility even in vaccinated individuals. The vaccines have been shown to be effective, but they are not perfect, and there are

vaccine breakthrough infections³⁶. Thus, it is crucial to maintain prevention strategies.

Given these challenges, Brazilian dental education must adopt strategies to strengthen it now and in preparation for other unexpected crises, including infrastructure adaptations and improving or installing ventilation systems equipped with air purifiers, to safely and responsibly guarantee the continuity of dental education.

Our work have focused on the urgent need to make adaptations on HVAC systems of the Brazilian dental schools overall, but the infrastructure of each dental school's clinics specifically was not assessed.

Thus, main limitation of this study was to consider that, in Brazil, almost all dental teaching clinics are equipped with air conditioners without mechanical renovation or air cleaning. However, this hypothesis is supported by some Brazilian studies and empirical observations of many teaching clinics^{11,12}. The strength of this study was to analyze a fundamental measure for preventing the spread of SARS-CoV-2 in dental clinics. Our study also undertakes a critical review and indicates that it is necessary to carry out a broader study to evaluate the HVAC systems of Brazilian dentistry schools, in order to reveal the risks of air transmission in these environments and guide new public measures to mitigate the COVID-19 pandemic.

5 CONCLUSION

Considering the documents analyzed in this study, it is critical to ensure that the dental environments equipped with air conditioning have air renewal mechanical devices.

Most of the documents analyzed strongly recommended that, in the COVID-19 scenario, AGPs should be carried out in respiratory isolation units with negative pressure and HEPA filters. In addition, the use of portable HEPA filter

units can be associated with HVAC systems to increase the effectiveness of the exhaustion time and decrease aerosol concentrations in the clinics.

The reopened undergraduate courses associated with the emergence of new variants of coronavirus and the possibility of an occurrence of future pandemics impose the need to readjust the physical environment of Brazilian dental teaching clinics. An alternative for teaching clinics equipped with window air conditioning and mini-split air conditioners could be to install exhaust fans and portable HEPA filtration units to perform the air changes and reduce aerosols inside environments.

RESUMO

Sistemas de climatização das clínicas de ensino odontológico brasileiras: uma revisão narrativa no contexto da pandemia da COVID-19

O surto de COVID-19 reafirmou a necessidade de manter adequadamente a ventilação dos ambientes odontológicos. Este estudo foi realizado para incentivar uma análise reflexiva sobre os riscos de contaminação do ar em clínicas de odontologia. Foi realizada uma revisão narrativa da literatura sobre as recomendações dos sistemas de aquecimento, ventilação e ar-condicionado (AVAC) em ambientes odontológicos, considerando os riscos de contaminação do ar nas clínicas de ensino odontológico brasileiras. A pesquisa bibliográfica foi realizada nas bases de dados PubMed e Google Acadêmico e foram incluídos os principais estudos que avaliaram os sistemas de climatização e unidades portáteis com filtragem de partículas de alta eficiência (HEPA) em ambientes odontológicos. Além disso, foram analisadas as diretrizes do Centro de Controle e Prevenção de Doenças, da Agência Nacional de Vigilância Sanitária, do Ministério da Saúde e de importantes instituições de diferentes países. Após a pesquisa inicial, foi realizada uma revisão das diretrizes e dos artigos que avaliaram o uso de unidades HEPA para melhorar a limpeza do ar. Essa análise foi feita por diferentes grupos de

pesquisadores. Todos os documentos mencionaram que a qualidade do ar dos consultórios odontológicos deve seguir os protocolos da legislação vigente para garantir a segurança dos ambientes. Eles reafirmam que a pandemia da COVID-19 torna imprescindível que os ambientes odontológicos, equipados com ar-condicionado, tenham dispositivos mecânicos de renovação de ar. Uma alternativa para as clínicas de ensino odontológicas brasileiras equipadas com mini *splits* ou ar-condicionado de janela poderia ser a instalação de exaustores e unidades portáteis de filtro HEPA para fazer as trocas de ar e reduzir os aerossóis no interior dos ambientes.

Descritores: Purificador de Ar. COVID-19. Filtro HEPA. Sistemas AVAC. Faculdades de Odontologia.

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