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Use of Personal Protective Equipment in Dental Care During COVID-19 Outbreaks and Options During Supply Shortages: An Integrative Review

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Abstract

Objective: to collate the recommendations on the use, extended use, reuse, and decontamination of personal protective equipment (PPE) in dental care during the COVID-19 outbreak, based on evidence found in the literature. **Materials and Methods:** searches were made of the following Brazilian and international databases on May 1, 2020: the Virtual Health Library Regional Portal, the Web of Science, and PubMed. The search strategy was based on the query ("individual protective equipment" AND "COVID-19") and retrieved publications from 2015 to 2020. Of cial infection prevention and control documents from different countries were also analyzed, as well as the recommendations of the American Dental Association. After applying the inclusion and exclusion criteria, a total of 20 studies were found to be eligible for the review. **Results:** there is a dearth of publications relating dentistry and PPE use during the pandemic. The extended use and reuse of respirators (N95, FFP2, FFP3) may be recommended during severe shortages, provided they are not damaged and they seal adequately. Nonwoven fabric gowns, surgical masks, gloves, and caps are single-use PPE. Eye protection may be reused after cleaning and disinfection. **Conclusion:** during the epidemic of SARS-CoV-2 we recommend wearing a N95, FFP2, FFP3 or equivalent respirator during aerosol-generating procedures, a face shield, which may be reused after cleaning and disinfection, and an impermeable gown, gloves, and cap, which should be discarded between patients.

Keywords: COVID-19; Coronavirus; Dentistry; Biosecurity; Epidemic; Personal protective equipment.

Introduction

On March 11, 2020, the World Health Organization declared a SARS-CoV-2 pandemic.[1] The epidemic began on December 31, 2019, in the Chinese city of Wuhan, Hubei province, from which the infection quickly spread across the world.[2] By May 7, 2020, 3,517,345 cases of COVID-19 and 243,401 deaths had been confirmed around the world.[3]

Since the pandemic started, health workers have been warned about the high occupational risk it represents.[4,5] Due to their proximity to patients' face, the presence of the virus in saliva and other body fluids,[6] and its transmission via aerosol,[7] dental surgeons are at particularly high risk of exposure to infection by SARS-CoV-2, being at the top of the list of professions with the highest occupational risk.[8,9]

The high rate of COVID-19 contamination amongst health workers has prompted researchers to identify the best measures to prevent this. Some studies have associated the high contamination rate with difficulty of access to personal protective equipment (PPE) as well as limited training in its correct use.[10,11,12,13,14,15]

In view of the real shortage of PPE and the high risk of contamination and transmission of this novel coronavirus in dental care, this article presents an integrative review of scientific articles, official disease surveillance documents, and recommendations published by the American Dental Association in order to analyze what is recommended in terms of the use, extended use, reuse, and decontamination of PPE in dentistry during the COVID-19 pandemic.

Material and Methods

This review was prompted by the following question: what are the recommendations concerning the use, extended use, reuse, and decontamination of PPE in dentistry during the COVID-19 pandemic?

The integrative review methodology involved the following steps: (1) selecting the research question; (2) retrieving studies of relevance; (3) selecting studies based on pre-established inclusion criteria; (4) analyzing and collating the data; and (5) summarizing and communicating the information.[16]

On May 1, 2020, searches were made of the Virtual Health Library Regional Portal, which provides access to Lilacs, SciELO, MEDLINE and other information sources, like open-access educational resources, websites, and scientific events, as well as Web of Science and PubMed. The search strategy was based on the following query: ("individual protective

equipment" AND "COVID-19"). Publications from 2015 to 2020 in English, Spanish, or Portuguese were retrieved, and no geographical restriction was imposed. The title, abstract, and keywords fields were searched. The documents were then included or excluded according to the following criteria: **a) inclusion criteria:** documents presenting technical criteria on the use, extended use, reuse, and/or decontamination of PPE for SARS-CoV-2; **b) exclusion criteria:** documents that only addressed clinical issues related to COVID-19 treatment and/or symptoms, documents that did not address SARS-CoV-1 or 2, studies that addressed only quantitative epidemiological issues relating to COVID-19, studies that addressed the social and psychological aspects of COVID-19, studies that debated public health policies, studies with questions related to agriculture or livestock, letters to editors, opinion articles, research notes, and audio files.

Seventy-two documents were retrieved using this search strategy, seven of which were found to be duplicates. The 65 remaining abstracts were read by two reviewers. When an abstract indicated that the document may fit the inclusion criteria, it was retrieved in full to confirm its eligibility for inclusion. When an abstract was read and it was unclear whether the study should be included, the respective full article was also obtained and read in full. After this procedure, 12 documents remained. In order to expand the scope of analysis of this review, official infection prevention and control documents from Brazil, the USA, the UK, and Australia were also searched, as well as the recommendations of the American Dental Association, which yielded another eight documents, bringing the total in the corpus for this review to 20. (Figure 1).

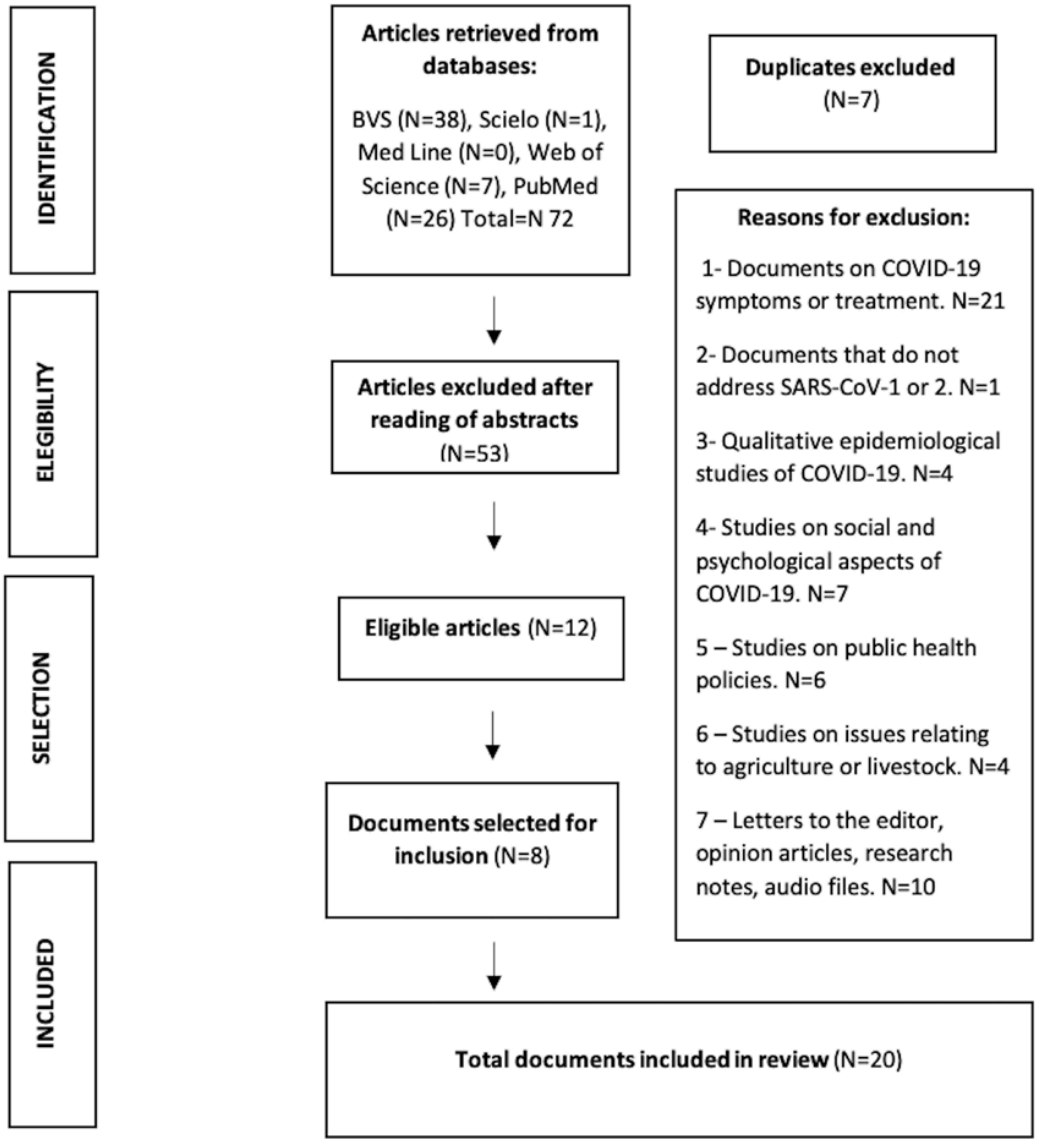

Figure 1. Flowchart of retrieval and selection of documents on the use of personal protective equipment in dental care during the COVID-19 pandemic.

Results and Discussion

Current evidence indicates that SARS-CoV-2 is transmitted between people via respiratory droplets and contact.[17] Airborne transmission may occur during aerosol-generating procedures, like intubation, ventilation, tracheostomy, bronchoscopy, and dental procedures that involve the use of a high-speed dental drill, a three-way syringe or ultrasound.[18] The potential for the virus to be transmitted when the disease is asymptomatic [19] makes it fundamental for additional precautionary measures to be taken during dental treatment for all patients, whether they are symptomatic or not.[20]

COVID-19 prevention and control strategies in dental care include screening and identification of suspected and confirmed cases, frequent hand cleaning, discarding PPE after each patient, cleaning of the consulting room, sterilization of all instruments, and adequate disposal of medical waste.[20] Given the shortage of PPE prompted by the pandemic, questions have been asked about the possibility of reusing and decontaminating disposable PPE.

Only four of the 20 documents included in this study provided specific guidance on dental care,[21,22,23,24] which only goes to highlight the of publications on the use of PPE in dentistry during the pandemic. The documents were assessed in terms of the type of PPE they recommended, and whether its extended use, reuse, or decontamination was possible in a situation of severe shortage. Table 1 shows the year of publication, country, method used, aims, and considerations on the extended use, reuse, and decontamination procedures suggested in the 20 documents reviewed.

The choice of PPE should be based on the work setting, the risk of transmission, and the dynamic of transmission of the pathogen (contact, droplets, aerosol), avoiding overuse or inappropriate use of PPE, which would only exacerbate its supply shortage.[17] Table 2 shows the PPE recommended per care setting and type of procedure.

Table 1. Documents retrieved in the integrative review: authors, year of publication, country of publication, method, objectives, and considerations about the extended use, reuse and decontamination of personal protective equipment

Reference	Methodology/Objectives	Extended Use	Limited Reuse	Decontamination
ADA.[21] USA, 2020	ADA Guidance. Recommends measures for minimizing the risk of COVID-19 transmission in dental care.	Not addressed	Eye protection	Wash eye protection with soap and water. Disinfect according to manufacturer's instructions.
Agalar *et al*.[47] Turkey, 2020.	Review. Assesses protection measures recommended for health professionals caring for patients with COVID-19.	Surgical masks for 4 to 6 hours provided they do not get wet or soiled.	Eye protection	Follow manufacturer's instructions
ANVISA.[23] Brazil, 2020.	Technical guidance. Provides guidance for health services, including dental care, with regard to infection prevention and control when caring for patients with suspected or confirmed SARS-CoV-2 infection.	Surgical masks, N95 respirators, and eye protection	N95 respirators only in cases of severe supply shortage. Eye protection after decontamination.	Wash eye protection with soap and water and disinfect with sodium hypochlorite or 70% ethanol.
Ministry of Health.[24] Brazil, 2020.	Technical guidance. Provides guidance on occupational safety and PPE for primary health care professionals, including dental surgeons.	Not addressed	Not addressed	Not addressed
Canova *et al*.[48] Switzerland, 2020.	Case report. Assesses the contamination of healthcare professionals without adequate PPE exposed to an initially undiagnosed COVID-19 case. Discusses guidance on the PPE needed during routine healthcare activities.	Not addressed	Not addressed	Not addressed

CDC.[22] USA, 2020.	Technical guidance. CDC guidance on infection control and prevention in dental care during the COVID-19 outbreak.	Not addressed	Eye protection	Follow manufacturer's instructions
CDC.[33] USA, 2020.	Technical guidance. CDC guidance on extended use and limited reuse of N95 respirators in health care settings.	N95 respirators only in case of severe supply shortage. Maximum time to be dictated by local needs.	N95 respirators only in severe supply shortages. Reuse no more than five times, always inspecting the integrity of the respirator before reuse. Discard after exposure to aerosol-generating procedure.	Not addressed
CDC.[39] USA, 2020.	Technical guidance. Provides guidance on the decontamination and reuse of respirators.	Not addressed	N95 respirators only in severe supply shortages. Wait five days before reusing.	Vaporized hydrogen peroxide, ultraviolet light, and moist heat have shown promising results in respirator decontamination, but have not yet been approved for routine practice.
National Guidelines for Public Health Units.[49] Australia, 2020.	Technical guidance. Provides a summary of disease surveillance and infection control recommendations, including PPE recommended when providing health care.	Not addressed	Not addressed	Not addressed
Heinzerling *et al*.[50] USA, 2020.	Case report. Assesses the contamination of healthcare professionals without adequate PPE exposed to an initially undiagnosed COVID-19 case. Discusses guidance on the PPE needed during routine healthcare activities.	Not addressed	Not addressed	Not addressed
Jin *et al*.[51] China, 2020.	Literature review. Presents evidence-based guidelines for the diagnosis and treatment of SARS-CoV-2 pneumonia. Gives guidance on PPE usage according to the setting and the exposure risk.	Not addressed	Not addressed	Not addressed
Lepelletier *et al*.[25] France, 2020.	Review. Clarifies the situations in which different types of masks should be used, in observance of official French guidelines.	Surgical masks for 4 hours provided they are not wet or soiled; N95 respirators for up to 8 hours.	Not recommended	Not addressed

Ministry of Health.[12] El Salvador, 2020.	Review article. Presents recommendations for PPE sterilization, when applicable.	N95 respirators, eye protection, and disposable gowns.	N95 respirators and cotton gowns, via sterilization processes.	N95 respirators by dry heat (against manufacturer's recommendations), ultraviolet light, vaporous hydrogen peroxide (disinfection method approved by the FDA). Cotton gowns washed and sterilized.
Pan American Health Organization.[26] Brazil, 2020	WHO Guidance. Summarizes guidance on mask use by health care workers during the epidemic.	Not addressed	Not addressed	Not addressed
Pan American Health Organization.[17] Brazil, 2020.	WHO Guidance. Summarizes guidance on rational PPE use by health care workers and decision-making during severe PPE supply shortages.	Surgical masks, N95 respirators, gowns and eye protection for 6 hours when caring for groups of patients with COVID-19.	N95 respirators, cotton gowns, and eye protection after decontamination.	Respirators: vaporized hydrogen peroxide, ethylene oxide, ultraviolet lamp (unvalidated methods). Cotton gowns: wash in hot water (60-90°C) then immerse in disinfectant (0.05% chlorine) for 30 min, rinse and dry. Eye protection: wash with soap and water and disinfect with sodium hypochlorite or 70% ethanol.
Pan American Health Organization.[52] USA, 2020.	WHO Guidance. Presents technical specifications and requirements for PPE use in SARS-CoV-2 in health care.	Not addressed	Eye protection after decontamination.	According to manufacturer's instructions
Public Health England.[18] UK, 2020.	Technical guidance. Reviews the PPE guidance for health care workers in the context of COVID-19.	FFP3 respirators	Eye protection	Follow manufacturer's instructions and infection control policies.
Public Health England.[34] UK, 2020.	Technical guidance. Reviews the provisional guidance in cases of acute PPE shortages during the pandemic.	N95/FFP2/FFP3 respirators, eye protection, and gown.	Cotton gown and eye protection after decontamination.	Eye protection: wash with soap and water and disinfect according to the recommendations of the local infection control program. Cotton gown: process in hospital laundry.
Verbeek *et al*.[27] Cochrane, 2020.	Systematic review. Assesses the effect that full-body PPE has on the protection of health care workers and which donning and doffing procedures represent the lowest risk of contamination.	Not addressed	Not addressed	Not addressed
Wax & Christian.[28] Canada, 2020.	Literature review. Presents considerations on patient screening, environmental control measures, PPE requirements, resuscitation measures, and planning of operations in intensive/critical care.	Not addressed	Not addressed	Not addressed

ANVISA: Agência Nacional de Vigilância Sanitária (Brazilian public health regulatory agency); CDC: United States Centers for Disease Control and Prevention, PPE: personal protective equipment; FDA: United States Food and Drug Administration, WHO: World Health Organization; FFP: filtering face piece.

Table 2. Personal protective equipment recommendations per setting and procedure

Setting	Activities	Type of PPE or procedure
Reception / Waiting Room	Filling out of data that does not involve direct contact	Maintain a physical distance of at least 1 meter. In the absence of direct contact with patients, wear surgical mask and eye protection. Frequent hand cleaning.
Consulting Room	Non-aerosol-generating procedures	Hand cleaning. Change surgical mask between patients * Change gloves, cap, and gown between patients. Eye protection
	Aerosol-generating procedures	Hand cleaning. N95, FFP2, FFP3 respirator or equivalent. Change gloves, cap, and impermeable gown between patients Eye protection (preferably face shield)
Hospital	Clinical assessment	Hand cleaning. N95, FFP2, FFP3 respirator or equivalent. Change gloves, cap, and gown between patients (ideally impermeable, if there is any risk of exposure to fluids or secretions) Eye protection (preferably face shield)
	Intensive/Critical Care	Hand cleaning. N95, FFP2, FFP3 respirator or equivalent. Change gloves, cap, and impermeable gown between patients Eye protection (preferably face shield)
	Oral Maxillofacial Surgeries and Emergencies	Hand cleaning. Operating room with negative pressure and HEPA filter (ideally for patients with suspected or confirmed COVID-19) N95, FFP2, FFP3 respirator or equivalent. Change gloves, cap, and impermeable gown between patients Eye protection (preferably face shield)

* Although, whenever possible, a N95, FFP2, or FFP3 respirator is considered more secure given the possibility of transmission via expiratory bioaerosol. FFP: filtering face piece, HEPA: high efficiency particulate arrestance (technology employed in air filters with a high capacity to capture particles).

In dentistry, respiratory protection against COVID-19 is a controversial issue. It is recommended that a new disposable surgical mask be used for each patient in non-aerosol-generating procedures, and a respirator with a minimum of 95% filtration efficiency for particles up to 0.3µ (N95, FFP2, FFP3, and equivalent) for aerosol-generating procedures.[12,23,24,25,26,27,28] However, even in non-aerosol-generating procedures, there is some concern that the natural processes of speaking and breathing may generate infectious aerosols (expiratory bioaerosols).[29] There is no evidence available that these expiratory bioaerosols can cause infection, but given the proximity between dental surgeons and their patients, the use of a N95 respirator (or equivalent) would be a safer option, even in non-aerosol-generating procedures. Similarly, respirator use is considered the safest option in hospitals, given the risk of the presence of the virus in suspension in the air.[30,31]

Some provisional, exceptional recommendations have been published to address the shortfall in the global supply of N95 respirators during the pandemic, such as the suspension of elective surgeries, the extended use or reuse of respirators and their decontamination.[17,32,33,34] Extended use refers to the practice of wearing the same N95 respirator for repeated close contact encounters with several patients without taking it off, while reuse involves removing it between patients.[32,33] The extended use and reuse of respirators is common practice during outbreaks of infectious respiratory disease epidemics and in non-emergency care of diseases not transmitted through contact, such as tuberculosis.[33] However, even when respirators are reused, there are restrictions on the number of times this can be done (limited reuse)[33].

None of the documents in this review mentioned the extended use or reuse of N95 respirators in dentistry. According to the US Centers for Disease Control and Prevention (CDC)[33] and the manufacturer's technical information sheet,[36] respirator reuse is not recommended after aerosol-generating procedures – which covers several dentistry procedures.

The decision as to whether to permit the extended use and reuse of N95 respirators is the responsibility of infection control committees at the hospitals or other institutions concerned, in consultation with disease/infection control agencies and public health authorities.[32,33,35,36] Although extended use and reuse are clearly advantageous for maintaining the supply of respirators, they are associated with some risks. During the COVID-19 pandemic, the biggest concern is the potential for contact transmission when the user touches the outside of the mask.[33,36,37] This risk can be minimized by adopting the following strategies: extended use (preferable to reuse), using a protective barrier over the respirator, not touching the outside of the respirator, hand cleaning before and after handling the respirator, and wearing gloves when adjusting a reused respirator.[23,33,35,36]

Respirators should be disposed of after aerosol-generating procedures, contamination with body fluids, contact with patients with other diseases transmitted by contact, and if there are any signs of damage to the respirator or it fails the user seal check.[33,35,36] The sharing of respirators by different professionals is not recommended[33] and no respirator should be reused more than five times to assure maintenance of respiratory protection.[33,38] Once donned, an N95 respirator should only be removed using its straps, never touching the outside surface, which it must be assumed is contaminated.[23,37]

One way to address the current supply shortage that is being discussed is the decontamination of N95 respirators for their reuse.[39,40] The factors that have to be considered for their effective decontamination are: the inactivation of the pathogenic microorganisms (including, but not limited to SARS-CoV-2), user safety and maintenance of filtration efficiency, fit and seal.[40]

The Brazilian Public Health Regulatory Agency, Agência Nacional de Vigilância Sanitária, has not issued any recommendations on the decontamination of N95 respirators for reuse amid concerns about the effect decontamination could have on their fit, seal, and filter performance.[41] In the USA, the only method currently approved by the Food and Drug Administration for temporary, emergency use is vaporized hydrogen peroxide.[42]

Based on studies of SARS-CoV-2 persistence on different surfaces[43] and of the survival of other viruses in N95 respirators,[44] the CDC suggests leaving the respirator for five days between each reuse.[32,39,40] It should be stored in an individual container that does not alter its format and is not airtight, so that any moisture can escape.[23,33,35] Even so, all due care should be taken when they are donned for reuse.[32,39,40]

The extended use of surgical masks is only recommended in hospital care settings reserved exclusively for patients with COVID-19 (cohort). In this case, they can be used for up to six hours, but should be discarded if they become wet or soiled.[17,25,34] Their reuse and decontamination are not recommended.[17,21,22,23,25,34] The extended use of surgical masks in dental care is not recommended due to the risk of cross contamination.[21] The use of a cotton fabric mask instead of a surgical mask or N95 respirator is not deemed to provide adequate protection for health professionals.[17,26]

Following the contact precaution guidelines, a disposable, back-opening, long-sleeved gown made of nonwoven fabric should be worn and discarded between patients. They should be impermeable if there is a risk of aerosol generation or contact with blood or other body fluids.[22,23] Disposable gowns should not be decontaminated, as the physicochemical process could affect the quality and characteristics of the material.[12]

The extended use of disposable gowns is only recommended in hospital care in settings where there is a cohort of COVID-19 patients. They may be worn for up to six hours, providing the patients are not infected with another disease requiring contact precautions and provided they do not get wet or soiled, in which case they should be replaced.[17,45] Alternatives in situations of severe shortage include wearing nonwoven fabric coveralls, washable cotton gowns, and these in combination with plastic aprons.[11,17,34,45] Coveralls offer increased body coverage and an improved perception of protection, but they are also more costly and the risk of contamination when doffed is higher.[27,28] Cotton gowns may be reused by washing in hospital laundries, but as they are not impermeable, they should not be worn in isolation in dental care.[12,17,45] Disposal of the gown/coverall/apron after each patient can be waived (extended use) if a long-sleeved, back-opening plastic impermeable apron is worn over it.[34,45] Although it is possible to disinfect a plastic apron afterwards, its disposal should be considered whenever possible given the difficulty of ensuring that every part of its surface has been decontaminated.

Double gloving should only be considered in procedures with a high risk of splitting.[17] The most effective measure for preventing contamination when doffing PPE is hand cleaning and the strict observance of each stage of the process.[17,18,23,27,34]

The conjunctiva should be protected by wearing goggles or face shield. Face shields are preferred as they protect a larger area and prevent contamination of respirators with droplets and aerosols.[21,23] Their extended use is acceptable in the hospital setting with groups of COVID-19 patients.[12,17,23,34,46] They should be cleaned with soap and water, then decontaminated with 0.1% sodium hypochlorite and rinsed or with 70% ethanol after each patient.[17,23,34,46] Their reuse is limited because decontamination tends to affect the anti-fog coating.[34]

Like any scientific study, this one has some limitations. Some arise from the limited number of studies into the persistence of SARS-CoV-2 on PPE, especially respirators. Furthermore, there are no clinical studies to assess the safety of the extended use and reuse of respirators in critical

situations. More research needs to be done into respirator decontamination, focusing on its impact on their seal and filter performance, as well as the elimination of microorganisms. Finally, the limited number of publications involving PPE for SARS-CoV-2 in dental care hamper evidence-based actions during the pandemic. As this is a new virus, new publications will likely bring to light new evidence that will lead to changes in the protection practices observed by health professionals.

Conclusions

Whenever there is a SARS-CoV-2 epidemic, the following recommendations are made for dental care:

- use of N95, FFP2, FFP3, or equivalent respirator, impermeable gown, gloves, caps, and face shield for aerosol-generating procedures;
- extended use and the limited reuse of respirators (N95, FFP2, FFP3) may be considered during severe supply shortages, provided their physical integrity and seal are unaffected;
- although some decontamination processes for respirators have shown promising results, until such practice is approved, a five-day gap between usages is suggested;
- nonwoven fabric gowns, surgical masks, gloves, and hair covers are single-use items and should not be reused;
- eye protection may be reused after cleaning with soap and water and disinfecting with 70% ethanol or 0.1% sodium hypochlorite.

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