

## ARTICLE OF REVISION

# Reprocessing of N95 masks or equivalent: a narrative review

## Reprocessamento de máscaras N95 ou equivalente: uma revisão narrativa

### Reprocesamiento de máscaras N95 o equivalentes: una revisión narrativa

Bianca Fontana Aguiar,<sup>1</sup>Jolline Lind,<sup>1</sup>Harli Pasquini Netto,<sup>1</sup>Yohanna Ramires,<sup>1</sup>Moacir Pires Ramos,<sup>1</sup>Jaime Luis Lopes Rocha.<sup>1,2</sup>

<sup>1</sup> Instituição onde o trabalho foi executado: Unimed Curitiba – Sociedade Cooperativa de Médicos, Curitiba, PR, Brazil.

<sup>2</sup> Pontifícia Universidade Católica do Paraná (PUC-PR), Curitiba, PR, Brasil.

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**Corresponding Author:**

Bianca Fontana Aguiar

bianca.aguiar@unimedcuritiba.com.br

## ABSTRACT

**Background:** During the COVID-19 pandemic, there was a shortage of N95 masks. **Objective:** To gather evidence on the possibility of reprocessing N95 masks and equivalents. **Methods:** Narrative review, with search performed on PubMed and Scholar Google. **Content and Conclusions:** Fourteen publications were included, including articles, technical notes: National Health Surveillance Agency, Federal Nursing Council and opinions from other international health agencies. The existence of some reprocessing methods was evidenced, such as: microwave-generated steam, hot moist heat, dry heat, germicidal ultraviolet irradiation, hydrogen peroxide, among the recommendations. In situations of lack of PPE, N95 masks or equivalent can be used beyond the expiration date designated by the manufacturer, prolonged or alternate use of masks by the same professional is also recommended. As for the reprocessing methods, they must not alter the electrostatic charge of the masks. Washing and steam sterilization have been shown to degrade them, while sterilization up to two times with hydrogen peroxide has provided acceptable results, since disinfection and reuse procedures may be necessary to combat the shortage of these materials. As an alternative to hydrogen peroxide, there is evidence for dry heat, but as long as it is used at an appropriate temperature.

**Keywords:** Personal Protective Equipment; Masks; Sterilization; COVID-19.

## RESUMO

**Justificativa:** Durante a pandemia de COVID-19, ocorre uma escassez de máscaras N95. **Objetivo:** Reunir evidências sobre a possibilidade de uso estendido e reprocessamento de máscaras N95 e equivalentes. **Métodos:** Revisão narrativa, com busca performada nas bases PubMed e Scholar Google. **Conteúdo e Conclusão:** Foram incluídas quatorze publicações, entre elas artigos, notas técnicas: Agência Nacional de Vigilância Sanitária, Conselho Federal de Enfermagem e pareceres de outras agências internacionais de Saúde. Evidenciou-se a existência de alguns métodos de reprocessamento, tais como: vapor gerado por micro-ondas, calor úmido quente, calor a seco, irradiação ultravioleta germicida, peróxido de hidrogênio, entre as recomendações. Em situações de falta de EPIs, as máscaras N95 ou equivalente podem ser usadas além da data de vencimento designada pelo fabricante, também se recomenda o uso prolongado ou alternado das máscaras pelo mesmo profissional. Quanto aos métodos de reprocessamento, os mesmos não devem alterar a carga eletrostática das máscaras. A lavagem e a esterilização a vapor, demonstraram degradá-las, já a esterilização em até duas vezes com peróxido de hidrogênio forneceu resultados aceitáveis, visto que procedimentos de desinfecção e reutilização podem ser necessários para combater a escassez desses materiais. Como alternativa ao peróxido de hidrogênio, existem evidências para o calor a seco, mas desde que se utilize em temperatura adequada.

**Palavras-chave:** Equipamentos de Proteção Individuais; Máscaras; Esterilização; COVID-19.

## RESUMEN

**Antecedentes:** Durante la pandemia de COVID-19, hubo una escasez de máscaras N95. **Objetivo:** reunir evidencia sobre la posibilidad de reprocessar máscaras y equivalentes N95. **Métodos:** Revisión narrativa, con búsqueda realizada en PubMed y Scholar Google. **Contenido y Conclusión:** Se incluyeron catorce publicaciones, incluidos artículos, notas técnicas: Agencia Nacional de Vigilancia Sanitaria, Consejo Federal de Enfermería y opiniones de otras agencias internacionales de salud. Se evidenció la existencia de algunos métodos de reprocessamiento, tales como: vapor generado por microondas, calor húmedo y caliente, calor seco, irradiación ultravioleta germicida, peróxido de hidrógeno, entre las recomendaciones. En situaciones de falta de PPE, se pueden usar máscaras N95 o equivalentes después de la fecha de vencimiento designada por el fabricante, también se recomienda el uso prolongado o alternativo de las máscaras por el mismo profesional. En cuanto a los métodos de reprocessamiento, no deben alterar la carga electrostática de las máscaras. Se ha demostrado que el lavado y la esterilización con vapor los degradan, mientras que la esterilización hasta dos veces con peróxido de hidrógeno ha proporcionado resultados aceptables, ya que los procedimientos de desinfección y reutilización pueden ser necesarios para combatir la escasez de estos materiales. Como alternativa al peróxido de hidrógeno, hay evidencia de calor seco, pero siempre que se use a una temperatura adecuada.

**Palabras-clave:** Equipo de Protección Personal; Mascarrillas; Esterilización; COVID-19

## INTRODUCTION

The 2019 coronavirus disease (COVID-19) spread worldwide early 2020, caused by the new coronavirus (SARS-CoV-2), which resulted in a large spectrum of presentation, including severe acute respiratory syndrome. It was considered a pandemic by the World Health Organization (WHO) on March 11<sup>th</sup>, as well as public health emergency of International Importance.<sup>1-4</sup>

The WHO's guidelines about prevention and control of the outbreak of COVID-19 recommend personal and respiratory hygiene and personal protective equipment (PPE), such as N95 masks or equivalent, for health professionals and patients suspected of SARS-CoV-2. As a result of the rapid spread of COVID-19, there was rapid consumption of such materials and the most important shortage of facial masks ever was installed. In hospitals, a lack of PPE will cause acceleration of the pandemic with many in hospital outbreaks.<sup>5-7</sup>

The N95 masks are the main PPE used to control airborne infections. COVID-19 is a disease with high risk of transmission and foreseeing shortage of such PPE the Brazilian Ministry of Health recommends that surgical and N95 masks be prioritized for all healthcare professionals during health assistance.<sup>8-11</sup>

With the global spread of SARS-CoV-2 pandemic, there was an international shortage of face masks. The lack of personal protective equipment (PPE) is caused by global low manufacturing capacity, mainly in China and the greater demand for health professionals.<sup>12-15</sup> The lack of this equipment causes great concern for health services.<sup>16,17</sup>

According to medical literature, there are three main different types of daily use masks: surgical masks, N95 masks and elastomeric respirators (the only one suitable for autoclave sterilization):<sup>18</sup>

- Surgical masks: cloth made masks designed for single use and projected to protect from large droplets, splashing or spraying of body fluids or other. In surgical masks, leakage may occur at the edges and they may not provide a reliable level of

respiratory protection against small particles in suspension.<sup>19</sup>

- Elastomeric respirators masks: They have full or partial facial coverage, with removable filter elements designed to be reusable. Some types of them can be sterilized in an autoclave, however, most of studies recommend that other methods of decontamination are faster and less damage to the mask elements.<sup>18</sup>

- N95 Masks: they are sealed and well-fitting masks. The N95 classification is designated by the minimum filtration efficiency of 95%, it is composed of several layers of polypropylene non-woven fabric (TNT).<sup>9</sup> The efficiency of this model is observed by the filtration capacity, caused by the electrostatic charge provided by the polypropylene fiber, whose action is fundamental to guarantee the protection of those who use it.<sup>20</sup> Decontamination methods, such as steam sterilization, washing and sterilization have been shown to degrade these types of breathing masks.<sup>18</sup>

To face this scenario, many strategies were suggested, such as prolonged use and reprocessing of N95 facemasks and equivalent. The aim of this review is to gather relevant publications about this subject.

## METHODS

To gather the relevant literature about reprocessing of masks, a narrative review was performed. This method is considered the basis for scientific production.<sup>21</sup> Also, it is described as: "narrative review articles are broad publications appropriate to describe and discuss the development or 'state of the art' of a given subject, from a theoretical or conceptual point of view". Finally, they are texts that constitute the analysis of the scientific literature in the interpretation and critical analysis of the author.

Studies published up to April 17<sup>th</sup>, in Portuguese, English or Spanish languages were considered for analysis. Databases used were Google Scholar and PubMed, which includes Medline and PubMed Central, where the following key-words were applied, linked by Booleans operators (AND, OR): "masks", "masks N95", "reprocessing". The reference lists of the included articles were also explored to identify relevant articles not founded in electronic searches. Searching for Technical Notes and guidelines was performed in the Brazilian National Health Surveillance Agency (ANVISA), Brazilian Federal Nursing Counseling (COFEN) and other international Health Agencies. Neither peer-review nor statistical analyses were conducted. Ethical Committee is not applicable for reviews.

## RESULTS AND DISCUSSION

In this review, fourteen publications were included, including articles<sup>18,29,31,34,35</sup>, technical notes: ANVISA<sup>25</sup>, COFEN<sup>26</sup> and opinions from other international health agencies.<sup>12,27,28,30,32,33,36</sup> The range of publication year was between 2010 and 2020.

### Decontamination methods<sup>18</sup>

#### Microwaves Generated Steam (MGS)

To decontaminate, plastic reservoirs with perforated lids are filled with 50 mL of tap water at room temperature, the contaminated N95 mask is placed on top of the assembly center and loaded into a commercially available microwave oven and exposed to radiation for two minutes (one minute on each side of the mask). Use of this method resulted in an average reduction of 5.06 logs of viable viruses (Figure 1a).<sup>18</sup>

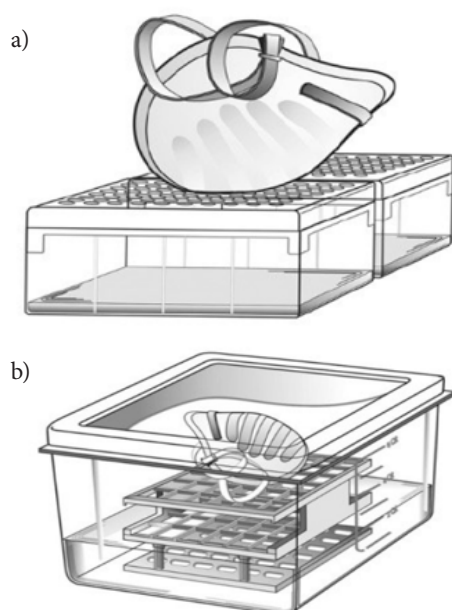
#### Warm Moist Heat (WMH)

A sealable container is filled with about a liter of tap

water. A support is placed in the container and this set must be heated to 65° for 3 hours in an oven, after the mask is placed on the support and returned to the oven for another 30 minutes. The use of this method resulted in an average reduction of 4.81 log of viable viruses (Figure 1b).<sup>18</sup>

#### Ultraviolet Germicidal Irradiation (UVGI)

A UV-C lamp (80W, 254 nm) is used to expose to UV radiation (average of 18 kJ/m<sup>2</sup>) for 15 minutes on each side of the mask (external and internal). The use of UVGI resulted in an average reduction of 4.81 logs of viable virus records. When using any disinfection procedure, healthcare professionals should not be subject to methods incapable of achieving optimal levels of reuse (ie, an average reduction of 6 viable virus logs). However, as the fight against Covid-19 progresses, disinfection and reuse procedures have to be used to combat the acute shortage of these material.<sup>18,23,24</sup>



**Figure 1.** Decontamination methods: **a)** Microwaves generated steam (MGS); **b)** Warm Moist Heat (WMH).

Source: Mechler (2020).<sup>18</sup>

#### Brazilian Guidelines and Recommendations

Technical Note GVIMS/GGTES/ANVISA nº 04/2020 (21.03.2020)<sup>25</sup>

Due to the lack of PPE's for healthcare professionals dealing with suspected or confirmed cases of COVID-19, N95 masks or equivalent can be used beyond the expiration date designated by the manufacturer. However, they may not meet the requirements for which they have been certified, as it may degrade, compromising the quality of the fit and sealing. This guidance was designed only because of the urgent demand caused by the public health emergency of COVID-19. Users who use these masks for longer periods should take the following precautionary measures before using N95 masks in the workplace:

- To inspect the N95 mask to ascertain its integrity (damp, dirty, torn, dented or creased masks cannot be used).
- To check that components such as strips, nasal bridge and nasal foam material have not degraded.
- To remove the mask, first remove it by the elastic bands,

being very careful not to touch the inner surface.

- To pack in a paper bag or envelope with the elastics out, to facilitate the removal of the mask.
  - Do not put the used mask in a plastic bag, as it may become damp and potentially contaminated.
- To carefully wash hands before touching masks  
To not touch your eyes, nose or mouth  
To wear protective goggles or facial shields
- One should not try to clean used N95 mask or equivalent with any product, since they are disposable and cannot be cleaned or disinfected for later use and when wet they lose their filtration capacity.

The Brazilian Federal Nursing Council (COFEN)<sup>26</sup> provides in the booklet "Guidelines on the placement and removal of personal protective equipment (PPE)" the following information:

- Surgical masks must not be overlaid with N95 masks or equivalent.
- Exceptionally, in situations of lack of supplies, the N95 mask or equivalent can be reused by the same professional, provided that mandatory steps are taken to remove the mask without contamination inside.

If available, a face shield can be used, and if the mask is intact, clean and dry, it can be used several times during the same shift by the same professional for up to 12 hours or as defined by the Control Commission. Hospital Infection (CCIH) of the health service.

#### International Guidelines and Recommendations

Guidance Nebraska Medicine COVID-19<sup>27</sup>

Temporary recommendations as long as there is a national and international shortage of protective equipment.

- Prolonged use is preferable to reuse, assuming it is safer for the employee to leave the mask and eye protection in place, to reduce the risk of self-contamination through frequent placement and removal of the same equipment.
- N95 masks can be reused or used over a long period of time, as long as they are capable of sealing, have not been used during an aerosol generation procedure, or have been soiled, damaged or moist due to sweat or loss of insensitive fluid by breathing.
- All supplies (N95) must be stored in designated, locked or protected areas (for example, Unit Manager / Supervisor / Leaders' Office or Laboratory Manager) and will be issued to staff with a paper bag or suitable container that allow breathability.
- The N95 storage bag must be named after the professional to avoid reuse by another person.

European Center for Disease Prevention and Control (ECDC):<sup>28</sup> "Cloth masks and mask sterilization as options in case of shortage of surgical masks and respirators"

- Available evidence shows that cloth masks are less protective than surgical masks and may even increase the risk of infection due to moisture, diffusion of fluids and virus retention. Particle penetration through tissue is reported to be high. In a cluster-randomized controlled study, cases of influenza-like illness and laboratory-confirmed viral illness were significantly higher among healthcare professionals who wore cloth masks compared to those who wore surgical masks. In total, ordinary fabric masks are not considered protective against respiratory viruses and their use should not be encouraged for professionals taking care of COVID patients. However, it may be considered for administrative group of workers if the shortage of surgical masks is in force.
- In the context of severe shortages of personal protective

equipment (PPE), and only if surgical or N95 masks are not available, cloth masks are proposed as a temporary solution.

- N95 are generally discarded after use, but can also be reused for a limited time, unless there is a risk of contamination by deposition of infectious particles on the surface. So far, manufacturers have had no reason or incentive to develop decontamination methods or to introduce reusable masks.

- SARS-CoV-2, the virus that causes COVID-19, survives in the environment, including on surfaces of various materials, such as iron, cardboard and fabric. This explains that there is a risk that the external surface of the masks used in patient care could be quickly contaminated. Contamination of the surface of respirators and surgical masks carries a risk of infection when reusing a surgical mask or N95.

- A 2006 report by the US National Academy of Sciences on the possibility of reusing N95 during an influenza pandemic discourages this practice for several reasons. First, the committee was unable to identify any existing methods that effectively remove the viral threat, are harmless to the user and do not compromise the integrity of the various elements of the facial mask. The report recommended alternative approaches, such as prolonged use. Contamination of the respirator's surface can be avoided by placing a simple mask over it or using a cleanable face shield.

- Due to the severe shortage of masks, several methods can be considered for sterilizing used masks. Steam sterilization is a procedure routinely used in hospitals. Mask deformation or failure testing after steam sterilization at 134 °C has been reported in a study conducted in the Netherlands, depending on the type of FFP2 mask used. Steam sterilization at lower temperatures is being studied.

- A study commissioned by the US Food and Drug Administration (FDA) showed that hydrogen peroxide (HPV) vapor was effective in decontaminating a single organism's N95 over several decontamination cycles. The respirator maintained its function even after 10 to 20 HPV cycles, but showed signs of degradation after that. A pilot study in the Netherlands indicated that the method is effective for two decontamination cycles without deformation, maintaining the filtration capacity assessed by a quick adjustment test, suggesting that the tested FFP2 masks (models without cellulose) can be reused up to twice. A possible caveat of this method is that harmful concentrations of hydrogen peroxide may remain in the mask for days after decontamination. Another concern is that more decontamination cycles can lead to deformation. In addition, filtration has not been properly evaluated.

- Gamma irradiation is a method used for large-scale sterilization of medical devices. The necessary equipment is generally not available in hospitals. One study indicated that a dose of 20kGy (2MRad) is sufficient for coronavirus inactivation. Ongoing studies on the use of gamma irradiation with a dose of 24kGy to sterilize respirators have demonstrated the possible deformation of the mask, compromising the internal filter layer and the fit of the mask on the face. A study in the Netherlands did not show deformation of an FFP2 mask after gamma irradiation with 25kGy, but the fit test after the decontamination process failed.

- Other methods such as ozone decontamination, ultraviolet germicidal irradiation and ethylene oxide were also considered. These methods are only considered as a last resort in the event of an impending shortage of PPE. They should be applied only after careful assessment of the situation and after exploring the possibility of rational and conscious use of resources. National public health authorities and groups studying these methods are encouraged to share their results as they become available.

Cleaning of reusable equipment before sterilization is recommended, but data on effective and non-harmful cleaning methods for single-use equipment are not available.

Dutch National Institute of Public Health and Environment (RIVM) <sup>12</sup>

- In a pilot study, a reprocessing method is found that leads to an acceptable quality of reprocessed facial masks. The caveat is that only limited research has been done on particle retention by reprocessed facial masks. This study shows that FFP2 face masks maintained their shape and were able to retain particles in a 'quick' test after sterilization (once and twice) with hydrogen peroxide.

- These masks consist mainly of polypropylene and do not contain cellulose.

- Processes applied for reprocessing: unused FFP2 masks were reprocessed at the Central Sterilization Department at University Medical Center Utrecht using the following processes (two masks per condition):

1. Cleaning process at 60 ° Celsius (12 minutes) with drying step, without detergent, and without chemical disinfection
2. Cleaning process with drying step, without detergent, thermal disinfection at 90 ° C (5 minutes).
3. Cleaning process with drying step, with cleaning agent (MediClean forte), thermal disinfection at 90 ° C (5 minutes)
4. Gas sterilization under low pressure of vaporized hydrogen peroxide (Sterrad NX 100 Express cycle with all clear technology (drying phase)); Applied up to four times.
5. Steam sterilization at 134 °C.

The effectiveness of the above processes is sufficient to inactivate the coronavirus based on knowledge of the inactivation of such viruses. Sterilization processes were developed to inactivate all microorganisms.

- Masks that were not visually deformed were subsequently subjected to an adjustment test in the RIVM.

- Cleaning processes with a disinfection step at 90 ° Celsius deformed the masks to the point that they were no longer usable. This also applies to the steam sterilization process. Masks sterilized four times with hydrogen peroxide were also deformed, which could compromise usability.

The adjustment tests were performed on sterile masks once, twice and three times with hydrogen peroxide and on a mask that had been cleaned without detergent at 60 ° C, as these masks had not been deformed and the elastic bands were intact. Masks sterilized once, twice and three times with hydrogen peroxide gave an average adjustment test value of 151, 103 and 28, respectively, indicating that the masks can be sterilized twice with hydrogen peroxide and can still be used.

- The mask that was cleaned at 60 ° C did not give a satisfactory result on the fit test. This was the case with the wet mask and the completely dry mask in the air. Based on these tests and preliminary exploratory results, the preliminary conclusion can be drawn that sterilization once and twice using a short hydrogen peroxide process provides an acceptable result, both after visual inspection and based on the results of the adjustment.<sup>29</sup>

- However, only one fit test was performed and only one type of FFP2 face mask was tested. Other available masks may, for example, contain cellulose. The presence of cellulose may be a limitation when using hydrogen peroxide.

- The applied processes have not been validated for the treatment of surgical masks.

Kansas Department of health and environment recommends:<sup>30</sup>

- Use alternatives to N95 respirators (for example, other classes of face mask with filter, elastomeric half mask) whenever possible;
- Implement practices that allow prolonged use and / or limited reuse of N95 respirators, when acceptable;
- Prioritize the use of N95 for health professionals at greatest risk of contracting infection or suffering complications from the infection.

Conservation status of PFF-2 respirators after use in hospital routine<sup>31</sup>

- The objective of an observational study was to quantify the damage inflicted on PFF-2 respirators over time of use and to estimate its period of validity in clinical practice.
- This study was based on the descriptive analysis of conical masks of the type PFF-2, collected by nursing assistants after one, five, 15 and 30 consecutive days of use, in a reference hospital for infectious diseases.
- From the fifth day on, all masks were dirty, while folding was observed in more than 80% of the equipment. Internal stains and folds were more frequent after 12-hour shifts than 6-hour shifts (IC 95%,  $p < 0.05$ ). 16.17% of the masks were lost on the fifth day and 38.93% after the 30th day of use.

The expiration date of the PFF-2 respirator, although it is not convenient to reuse it, should be limited to five days.

The Society of American Gastrointestinal and Endoscopic Surgeons recommends:<sup>32</sup>

In long-term use of N95, there are reports that it can be safe for up to 8 hours, they must be used together with the face shield.

Since the coronavirus loses its viability after 72 hours, rotation and reuse strategies are recommended. The extent to which there is no dirt on the masks and can be reused up to five times.

Mask rotation is implemented, that is, they must be used on alternate days. Thus, it is possible for them to dry, and what makes the virus unviable (> 72 hours).

In this technique, the ideal storage for the masks should be in a breathable material, with a paper bag being the best option.

As for the reprocessing methods, it is recommended that the filtering capacity and the electrostatic charge are not altered. Some methods are described below:

- Vaporization with Hydrogen Peroxide: the decontamination enabled several processing cycles with preservation of the N95 function. The FDA has approved this technique as an emergency method in the event of a PPE shortage. It is reinforced that this form of reprocessing should be applied only in models that do not contain cellulose.

- UV treatment: this measure requires specific dosing protocols and the area's illumination surface to ensure adequate inactivation of viral particles.

- Moist heat: Heating to 60-70 ° C and 80-85% relative humidity has been shown to be effective in reducing the flu virus, however, data are limited.

- Dry heat: This technique consists of dry heating at temperatures of 70 ° C for 30 minutes, thus allowing the virus to become unviable, without changing the integrity of the filter.

- The use of microwaves for reprocessing is not recommended, as it can be flammable.

The New York City Department of Health and Mental Hygiene guides:<sup>33</sup>

The critical shortage of N95s and other PPE required some changes, including the reuse of single-use items. However, health professionals can be contaminated and to reduce this risk, considering that the virus can survive for 72 hours on certain surfaces, it is suggested:

- To protect the N95 with a face shield, as the risk of reexposure may be minimal.
- To use one N95 per day of the week, with identification of who used.
- After use store in a paper bag or other clean and breathable container at the end of each shift and keep in a warm and dry place.
- The order of use is repeated every seven days.

Among the ways of reprocessing identified, the ones that showed the best results were Hydrogen Peroxide and dry heat, however, the latter technique should not be performed at high temperatures, as the mask can suffer degradation, the ideal temperature would be around 75 ° C for 30 minutes. The use of sterilizers with ethylene oxide, if not used properly, presents a high risk of toxicity. Methods that require disinfectants or moist heat change the electrostatic charge, that is, they are not indicated.

For reprocessing, the use of a domestic oven or microwave is not recommended, as both increase the risk of explosion.

Can N95 respirators be reused after disinfection? And how many times?<sup>9</sup>

The mechanisms for reprocessing materials exposed to bacteria and viruses have the following effects: protein denaturation, highlighting products with alcohol and heat sources, in the destruction of DNA / RNA, the agents are UV rays, hydrogen peroxide and oxidizers.

Some tests of possible reprocessing techniques were carried out, they correspond to the following results:

- Dry, even wet, heating, provided that at temperatures <100 ° C, the characteristics of the N95 mask remain unchanged.
- The use of steam, in long periods of use, can degrade the material.
- UVGI rays are recommended only if in doses less than 1000 J/cm<sup>2</sup>.
- When solution methods were chosen, they damaged the mask filtration, not being a viable option.

Decontamination and reuse of N95 respirators with hydrogen peroxide vapor to address the worldwide shortage of personal protective equipment during the SARS-CoV-2 pandemic (COVID-19):<sup>34</sup>

**Table 1.** Reprocessing techniques.

| Method            | Structural integrity of the mask                     | Viral Stability or Inactivation            | Filtration efficiency (%) |
|-------------------|--|--|---------------------------|
| UGIV              | Performance and appearance were not affected         | Undetectable levels of infectivity         | 95.50%                    |
| Hydrogen peroxide | Performance was not affected                         | Tendency towards inactivation of pathogens | 99.00%                    |
| Calor úmido       | There was partial separation of the nasal cushion    | Viral deactivation                         | unvalued                  |
| Ethylene oxide    | Performance and appearance have not changed          | unvalued                                   | unvalued                  |
| Dry Heat          | Performance and appearance have not changed (75 ° C) | Viral deactivation                         | 96.21%                    |
| Steam             | There was a change                                   | unvalued                                   | 94.74%                    |

Source: Adapted from references<sup>9,33,36</sup>

Reprocessing with hydrogen peroxide was analyzed by Duke University, and presented the following results:

- After applying the technique, the N95 masks did not change, the electrostatic charge was not compromised.
- Previous studies corroborate the findings, and they state that the filtering capacity was maintained even after 50 reprocessing cycles.

Methods for cleaning and reusing N95 masks proposed by the N95 inventor:<sup>35</sup>

One of the developers of the N95 mask model, Peter Tsai, indicates some reprocessing and reuse techniques, such as:

Dry Heat: Masks heated for 30 minutes at 70°C, the filtration efficiency remains between 92.4% - 98.5% after this method.

Rotation: Alternate use of masks during the week.

Techniques with alcoholic products are not recommended, as they alter the filtration capacity.

Final Report for the Bioquell Hydrogen Peroxide Vapor (HPV) Decontamination for Reuse of N95 Respirators:<sup>36</sup>

Em tempos de falta de Epis, o peróxido de hidrogênio é uma alternativa de reprocessamento, ele apresenta baixa toxicidade e apresenta bons resultados em frente ao reuso das máscaras N95.

Em um estudo piloto, as máscaras N95 foram submetidas a diversos testes para viabilidade, as amostras analisadas constataram que não houve degradação visível quando as mesmas foram submetidas entre 10 ou 20 ciclos. A eficiência da filtração não sofreu alterações, manteve-se em torno de 99%.

Salienta-se que técnicas para a finalidade de reuso são viáveis visto o contexto que a sociedade vivencia neste momento.

## STUDY LIMITATIONS

Despite the strength of scientific evidence being considered low due to the impossibility of reproducing its methodology, narrative reviews can contribute to the debate of certain themes, raising questions and collaborating in the acquisition and updating of knowledge in a short period of time.

## CONCLUSIONS

In situations of lack or shortage of PPE's, cloth masks are proposed as a temporary solution and N95 masks or equivalent may be used beyond the expiration date designated by the manufacturer. Another alternative is prolonged use of the masks by the same professional. The validity period of N95 masks must be limited to five days or as defined by the Hospital Infection Control Commission (CCIH).

It is also recommended to use masks rotation strategies, in which they must be reused alternately during the week. Thus, they are allowed to dry and the virus is no longer viable (> 72 hours).

As for the reprocessing methods, they must not alter the filtration capacity and electrostatic charge of the masks. Some methods were tested, such as: Steam generated by microwave (MGS); Hot moist heat (WMH), UV radiation. However, it is noteworthy that none of these methods is capable of achieving ideal levels of reuse. However, disinfection and reuse procedures may be necessary to combat the scarcity of these materials. Sterilization up to two times with hydrogen peroxide provided an acceptable result, however, only one adjustment test was performed and only one type of N95 face mask was tested. The FDA approved this technique given the possibility of a shortage of PPE's.

The reprocessing with dry heat, at temperatures around 70 ° C, lasting 30 minutes, made it possible to inactivate the virus, without structural damage or electrostatic alteration.

To date, manufacturers have had no incentive to develop methods of decontamination or to introduce reusable masks.

## OPINION WITH REGARD TO N95 MASKS

In view of the situation of excessive demand for the use of PPE during the epidemic period, the following recommendations are acceptable:

- The best measure is the prolonged use of the masks, whose validity period of use must be limited to five days or as defined by the Hospital Infection Control Commission (CCIH) of the health service, as long as there is no gross contamination or loss mask integrity.

- Another strategy is the rotation of the masks, in which they can be reused alternately during the week.

Note: The masks must be properly handled to avoid contamination and preferably use facial shield.

- Regarding N95 masks without cellulose, reprocessing is acceptable bearing in mind that there is no significant structural damage or alteration of the electrostatic charge, with maintained filtration capacity and with viral inactivation. The suggested methods are:

1. Hydrogen peroxide chamber

2. Dry Heat (70 ° C for 30 minutes)

Note: Provided they are not reprocessed more than twice. See the description of the reprocessing techniques mentioned above.

- After reprocessing, they must be properly packaged and identified.

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