SARS-CoV-2, initially known as 2019-nCoV, was declared as a pandemic by the WHO in March 2020 and is a major issue of global concern as it has been found to affect the respiratory tract of human beings through coughing, sneezing, and saliva. It exploits angiotensin converting enzyme 2 receptor found in the lower respiratory tract and the infection entry points are the eyes, nose, and mouth. The size of this virus ranges from 0.06 - 0.14 microns and is mainly transmitted through fine microdroplets (droplets) and core droplets (aerosol). Fine droplets that are > 5 μm in diameter can spread up to 1 m. The particles < 5 μm in diameter known as aerosols have a diffusion capacity greater than 1 m. Smaller aerosol particles, ranging from 0.5 to 0.0 microns, can penetrate and lodge in smaller passages of the lungs, causing an infection. The period of these particles for which they are suspended in the air, depends on the size of the particle, flow of the air, relative humidity, and the settling velocity.

As it has raised an alarm for the health of human beings, especially the health care workers all over the world, the ones associated with aerosols generating procedures need to take special precautions. A study showed the expression of ACE2 receptor through epithelial cells in the oral cavity; the expression was more in the tongue as compared to the buccal and gingival tissues, indicating oral mucosa to be an important conduit for the virus transmission. As it is not possible for dental professionals to avoid the aerosol generating procedures, one must be overcautious with the protective measures while resuming duties.

Why do we need to cover the face?

According to the World Health Organization (WHO), people can transmit the virus to others while showing no signs or symptoms of being infected with COVID-19 themselves. This is why, the Center for disease control and prevention (CDC) has given some guidelines for the general public to keep the mouth covered when stepping outside in public settings, like grocery stores, public transport etc. especially where social distancing may not be maintained. The widespread use of face masks by the public might help slow the spread of the virus. To address concerns regarding different types of masks for protection, below are listed various types of masks available along with their specifications and benefits.
of viruses, germs, and bacteria\textsuperscript{18}). So, 1-ply and 2-ply may not be consid-

ed because of developmental disabilities, mental conditions and neurologi-

cal conditions as well as breathing problems\textsuperscript{34}. A respirator with a valve

in the mask to avoid the spread of viruses, germs, and bacteria\textsuperscript{18}. So, 1-ply and 2-ply may not be consid-
ered medical masks. A surgical mask provides a double protection by

providing the patient against the microorganisms produced in a dental
health care system and secondly, the dental health care provider is pro-
tected from the splash, contaminated blood, spatter etc. while working

on the patient and preventing the transfer of body fluids and microor-

ganisms between the two\textsuperscript{15}. Surgical masks are regulated under 21 CFR
878.4040\textsuperscript{15}. Although these masks can block splashes, large droplets,

and sprays, these do not filter exceedingly small particles as they do not

have a proper seal on the mouth and nose area. This increases the chanc-
es of infection from germs and other contaminants\textsuperscript{17} and viral carriers

like InFluenza and COVID -19, which is transmitted by aerosols\textsuperscript{20,22}. They

are not reusable, once soiled; need to be discarded and replaced.

Donning and Doffing:

Identify the "inside" of the medical/procedure mask- this should be

white\textsuperscript{21}. This side faces the mouth while the colored side faces out. The

metal nose clip should be on the top. With the white side facing in and

the nose clip on the top, place the loops around the ears or tie the straps

at the neck and at the crown of your head. Pull the top and bottom of the

mask to expand the folds. The top of the mask should extend above your

nose, and the bottom should extend below your chin. Put the soiled

mask or the mask once used in a plastic bag and then in the bin accord-
ing to the color coding followed, then wash the hands properly. To

remove the mask, one should do so from behind to avoid touching the

front surface\textsuperscript{18}.

Filtering face piece respirators (FFR), or respirators

Respirators can be classified as

1. Disposable half mask (Fig. 1c)
2. Elastomeric half face piece mask (Fig. 1d)
3. Elastomeric full face piece mask (Fig. 1e)

Common types used in health set ups are, disposable half-mask fil-
tering face piece respirators (FFRs)\textsuperscript{24}. Respirators are not routinely

used, as their role is mainly limited to high-risk situations like during
aerosol generating procedures on patients with respiratory infections\textsuperscript{25}.

Respirators are fit to the face and are designed to protect the wearer

from hazardous airborne contaminants. They offer a balance of filtration
and breathability. These masks have tangled fibers to filter pathogens in
the air, and they fit close to the face. The edges form a good seal around
the mouth and nose\textsuperscript{26}. Certified FFRs must ensure unhindered breathing
with maximum resistances during inhalation and exhalation\textsuperscript{27}.

An N95 respirator (Fig 1c)

To prevent the airborne viruses or particularly aerosols containing

virus from entering the body, a device is required which will form a

tight seal around the mouth and nose that provides efficient filtration of
95% or above particle filtering efficiency for a median particle size of
0.3 μm\textsuperscript{28}. This refers to an N95 (disposable half mask filtering face
piece respirator), that is the most widely used FFR and filters 95% of tiny
particles or higher. This filtering face piece respirator is certified by
the CDC/National Institute for Occupational Safety and Health (NIOSH).
It is designated for protection against aerosols, though it is

darker to breathe through it in comparison to a surgical face mask\textsuperscript{29}.

It effectively filters the airborne particles, and the edges form a
proper seal around the mouth and nose however, when in contact with
an infected person, it does not provide 100% protection. Centers for
Disease Control and Prevention (CDC)\textsuperscript{30} has recommended N95 masks
along with other protective measures to be used by health care profes-
sionals while working on front lines\textsuperscript{29,31}. Surgical N95 Respirators are

the ones, most commonly used by health care providers and are a subset
of N95 Filtering Face piece Respirators (FFRs), often referred to as
N95s. Surgical N95 respirators are both approved by NIOSH as an N95
respirator and also cleared by the FDA as a surgical mask\textsuperscript{32}.

These products are frequently referred to as medical respirators,

healthcare respirators, or surgical N95s. Though the N95 and Surgical
N95 look similar, the main difference lies in the fluid resistance and the
resulting FDA clearance of surgical N95a. Surgical N95 is to be used by
the health care workers while performing surgeries and other procedures
exposing them to high streams of body fluids\textsuperscript{33}. For the areas of poten-
tial hazard, where airborne droplets are present by cough and sneeze an
N95 mask can be worn.

Precautions with an N95 Respirator

It is not advisable for use in case of people with compromised
health conditions and breathing problems\textsuperscript{34}. A respirator with a valve
should not be used in operatories as it filters only the inhaled air and not
wearer’s exhalation, putting everyone around at risk. Though it helps in
making breathing out easier and reduces the heat and moisture build up
inside the mask which makes it more comfortable to wear\textsuperscript{35}.

So, to protect the others, a surgical mask can be put over the valved
respirator. As all FDA-cleared N95 respirators are made for one-time use,

it must be discarded immediately once soiled. N95 respirators are class II devices regulated by the FDA, under 21 CFR 878.4040, and

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Common types used in health set ups are, disposable half-mask filtering face piece respirators (FFRs)\textsuperscript{24}. Respirators are not routinely used, as their role is mainly limited to high-risk situations like during aerosol generating procedures on patients with respiratory infections\textsuperscript{25}.

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It effectively filters the airborne particles, and the edges form a proper seal around the mouth and nose however, when in contact with an infected person, it does not provide 100% protection. Centers for Disease Control and Prevention (CDC)\textsuperscript{30} has recommended N95 masks along with other protective measures to be used by health care professionals while working on front lines\textsuperscript{29,31}. Surgical N95 Respirators are the ones, most commonly used by health care providers and are a subset of N95 Filtering Face piece Respirators (FFRs), often referred to as N95s. Surgical N95 respirators are both approved by NIOSH as an N95 respirator and also cleared by the FDA as a surgical mask\textsuperscript{32}.

These products are frequently referred to as medical respirators, healthcare respirators, or surgical N95s. Though the N95 and Surgical N95 look similar, the main difference lies in the fluid resistance and the resulting FDA clearance of surgical N95a. Surgical N95 is to be used by the health care workers while performing surgeries and other procedures exposing them to high streams of body fluids\textsuperscript{33}. For the areas of potential hazard, where airborne droplets are present by cough and sneeze an N95 mask can be worn.

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It is not advisable for use in case of people with compromised health conditions and breathing problems\textsuperscript{34}. A respirator with a valve should not be used in operatories as it filters only the inhaled air and not wearer's exhalation, putting everyone around at risk. Though it helps in making breathing out easier and reduces the heat and moisture build up inside the mask which makes it more comfortable to wear\textsuperscript{35}.

So, to protect the others, a surgical mask can be put over the valved respirator. As all FDA-cleared N95 respirators are made for one-time use, it must be discarded immediately once soiled. N95 respirators are class II devices regulated by the FDA, under 21 CFR 878.4040, and CDC NIOSH under 42 CFR Part 84 and they are meant for health care workers for one time use\textsuperscript{36}. N95 respirators do not provide full protection, if the proper seal is not formed around the edges, so these are not meant for people with facial hair and children. Mask should be worn
Filtration Efficiency of Different Masks

Can it be reused?

Ideally meant for one-time usage but to tackle a crisis like situation, experiments are being done for decontamination and reuseage of masks\(^1\). Decontamination has to be done as per manufacturer's instructions keeping in mind that it may reduce the original filtering capacity of the mask\(^2\). Although Ultraviolet germicidal irradiation (UVGI), vaporous hydrogen peroxide (VHP) and moist heat are the most promising decontamination procedures, their efficacy against COVID-19 has not been proven yet. According to a technical bulletin from 3M (Maplewood, MN)\(^3\), there are four criteria a good decontamination method should satisfy: it should \(1\) be effective against the target organism, such as the SARS-CoV-2 virus that causes COVID-19; \(2\) not damage the respirator’s filtration; \(3\) not affect the respirator’s fit; and \(4\) be safe for the person wearing it.

As of March, however, 3M continued to insist, that “no disinfection method has met all four” of the criteria mentioned above, when repeated five to ten times\(^4\). In an early April update\(^5\), the manufacturer states that while hydrogen peroxide and other decontamination methods are still being evaluated, baking, steaming, or autoclaving are not recommended “due to significant filter degradation.”

Half piece and full piece face mask respirators (Fig 1d, Fig 1e)

These are tight fitting elastomeric respirators, where the face pieces are made of synthetic or natural rubber material, can be cleaned, disinfected, stored, and re-used, and are available as an alternative to N95 FFRs which are disposable half mask filtering face piece respirators (FFRs)\(^6\). Based on their NIOSH approval, they can provide equivalent protection to N95 FFRs though they are not cleared by FDA for fluid resistance. They have a replaceable filter cartridge and can offer higher assigned protection factors (APFs) than N95 FFRs. Elastomeric part provides proper sealing surfaces along with a better fit with adjustable straps. The filter media are sufficient to drop droplet and viral size particles when worn correctly for the duration of the exposure\(^7\). Respirators with full face pieces have the same filter considerations and provide greater protection because of better sealing characteristics along with more protection to the face and very importantly, the eyes.

Donning and doffing

There should be appropriate training on donning and doffing procedures before using face mask respirators. The materials that comprise the elastomeric components of NIOSH-approved respirators vary among manufacturers, as OSHA only requires replacing filters when soiled, contaminated, or clogged. The elastomeric part like face piece, valve covers, valves, and straps must be cleaned and disinfected as per manufacturer's instructions, depending upon the material used for the elastomeric part. Depending on use, one manufacturer recommends the filter be discarded after each use, while another recommends the filter cartridge be disposed of no later than 30 days after the first use if no oil mist is present\(^8\). For proper donning and doffing of the respirator, both CDC and OSHA have videos illustrations\(^9\).

Cleaning and Disinfection of elastomeric part:

Clean the surface of the filter cartridge with a detergent or soap and warm water before disinfestation which must be done in a well-ventilated area along with other protective measures like gown, face shield and nitrile gloves\(^10\).

Cleaning

Filter media contact must be avoided with cleaning solutions. A soft cloth dampened with warm water approximately 49°C (120°F) containing a mild pH neutral (pH 6-8) detergent can be used for cleaning using a mechanical wiping action\(^11\).

Disinfecting

The effectiveness of filter cartridge disinfection solution may be questionable as the disinfectant may not reach up to all the crevices of filter cartridge housings for sufficient time period to be effective and because of degradation of filter media by disinfectant though there are some respirators which come with cartridges that prevent disinfectant contact with the filter media. If available, preference should be given as these cartridges may be wiped down repeatedly. For disinfection, diluted household bleach solutions, alcohol solutions with at least 70% ethyl alcohol, and EPA-registered household disinfectants should be effective against coronavirus\(^12\).

Edelweiss Virustatic Shield: (Fig 1f)

The shield has a unique Viruferrin antiviral coating which along with the base material forms a protective face covering. It was originally developed to fight the flu related epidemics and now has been proven scientifically to be effective against coronavirus as confirmed by independent laboratory tests from the British-led scientists at Vis Mederi at the University of Siena\(^13\). It provides a proper seal and contour around the face in the areas of critical infection points: nose, mouth, and ears, is extremely comfortable and breathable because of the presence of a single layer. The protein coating mimics the body's immune system to trap and disable viruses. It acts as a barrier, attracting, trapping, and killing viruses in microscopic airborne particles 15 times smaller than a human hair\(^14\).

Can it be reused?

It can be worn 50 times more than a disposable single use mask. It can be washed and reused\(^15\). The Virustatic Shield works from both sides, so it is particularly useful for people who believe they have coronavirus and want to prevent themselves from passing it on to those they are in contact with.

DISCUSSION

Procedures in dentistry like endodontic procedures, ultrasonic scaling, crown preparations produce aerosols which can be in the air for 10-30 minutes in the operatory after the procedure\(^16\). A study found that maximum aerosol contamination was found in the assistant's zone, followed by the operator's zone\(^17\). The aerosols and splatter generated by the dental procedures are contaminated with virus and bacteria\(^18\). Aerosols are solid and liquid particles (< 50 μm diameter) which remain suspended in air for a long time in the operatory. Splatter is a mixture of air, water and/or solid substances (50 μm to several mm in diameter). The COVID-19 virus measures around 120 nm (0.12 μm) in size.

Amongst various personal protective measures, masks play a particularly important role for dental health professionals as the main concern is to provide the maximum care without getting infected and infecting the others as well. Different masks have been designed to meet the clinical needs depending upon the requirement of the situation\(^19\).
The main difference between a 1-ply, 2-ply and 3-ply face mask lies in their function and level of protection. A 3-ply mask has 3 individual layers made up of a melt-blown material placed between the non-woven fabric that can protect one from airborne viruses\(^6^2\). The middle layer contains a high-level static filtration to effectively block micro dust and bacteria. The 2-ply face mask is a hygienic face mask that is cheap and made from the same material fabric, polypropylene, or another non-woven kind of material. 1-ply and 2-ply face masks are for sanitary and hygienic purposes in a restaurant setting mainly for food handling and for a spa setting\(^6^2\).

Surgical masks (SMs) can filter particles of 0.04-1.3 μm\(^6^2\), and are commonly used to physically block particles such as droplets. But they have a poor fit and there is a possibility of aerosol aspiration. SMs are not commonly used to physically block particles such as droplets. But they are available in multiple sizes to fit a range of faces, are easy to maintain, and are popular among healthcare workers 63\(^,\) and are highly effective against aerosols 70-73\(^,\).

Disposable filtering facepiece respirators (DFHFRs), classified as air-purifying respirators, have been widely used and accepted by healthcare workers\(^6^5\). The important point to understand is the difference between a Surgical mask (Fig. 1b) and a Procedural mask (Fig. 1g). A surgical mask is meant to be used in operating room to protect the patient and the environment and the health care worker from the bio-aerosols (non-oil based particles) 79,80\(^,\).

Table 1: ASTM performance criteria for grading masks

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Bacterial Filtration Efficiency (BFE)</th>
<th>Particulate Filtration Efficiency (PFE)</th>
<th>Fluid Resistance</th>
<th>Differential Pressure (Delta P)</th>
<th>Flame Spread</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Measures the percentage of bacteria filtered when challenged with a bacteria-containing aerosol</td>
<td>Measures the percentage of submicron particles that will be filtered</td>
<td>Measures the mask’s ability to minimize the amount of fluid that can transfer from the outer layer to inner layer from a splash or spray</td>
<td>Measures the air flow resistance of the medical mask</td>
<td>Measures ability to withstand exposure to a burning flame for three seconds</td>
</tr>
<tr>
<td>ASTM tests with a droplet size of 3 microns containing Staphylococcus aureus (6–8 microns)</td>
<td>The higher the percentage, the better the filtration</td>
<td>ASTM tests with synthetic blood at pressures of 80, 120, or 160 mmHg to qualify for low, medium, or high fluid resistance</td>
<td>An objective measure of breathability</td>
<td>ASTM requires a Delta P of less than 5.0 for moderate or high barrier masks</td>
<td></td>
</tr>
<tr>
<td>In order to receive medical/surgical grade mask, a minimum of 95% filtration is required</td>
<td>The greater the resistance equals better filtration, yet less breathability</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate or high protection masks must have a bacterial filtration rate of 98% or greater</td>
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<td></td>
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</tr>
</tbody>
</table>

Masks should be selected based on design, fit, and filtration requirements of the risk involved in the different procedures. The American Society of Testing and Materials (ASTM), an international standards organization has given a classification for the medical masks depending on Bacterial Filtration Efficiency (BFE), Particulate Filtration Efficiency (PFE), Fluid Resistance, Differential Pressure (Delta P), and Flame Spread which is recognized by FDA in USA\(^6^6\). (Table 1.2).

Disposable filtering half-facepiece respirators (DFHFRs), classified as air-purifying respirators, have been widely used and accepted by workers in various industries and the general population as they are available in multiple sizes to fit a range of faces, are easy to maintain, offer little hindrance to wearers\(^6^7\), and have the highest rating and evaluation in weight and convenience\(^6^8\).

Among DFHFRs, NIOSH-approved N95 filtering facepiece respirators or higher are recommended for healthcare workers against airborne infectious diseases such as Ebola\(^6^9\).

One needs to understand the NIOSH classification to use the appropriate mask for a procedure. The particulate filtering disposable facepiece respirators (FFRs) are classified as N (not resistant), R (somewhat resistant), and P (strongly resistant) for protection against oils. The second rating is according to the percentage of airborne particles that are filtered in testing when using the most penetrating particle size. The one filtering 95% gets a rating of 95, the one filtering 99% gets 99 rating and the one filtering 99.7% gets 100 % rating\(^6^8\) (Table 3). The same classification is followed for the filters of reusable half face and full face respirators which also depends upon the resistance to degradation by oil-based aerosols; N series filters (not oil resistant types), R series filters (somewhat oil-resistant, and, in industrial use, typically have an 8-hour time-use limitation) and P series filters (oil-resistant and rarely have use-time limitations) They also follow the same rating for filtering efficiency as followed by disposable N95 i.e. 95,99 and 100. The European Standard (EN 149: 2001) classifies FFRs into three classes: FFP1, FFP2, and FFP3 with corresponding minimum filtration efficiencies of 80%, 94%, and 99%. An FFP2 is comparable to a N95 FFR\(^6^8\).

The various indications of how to use FFRs is based on their capacity and quality of filtration. The FFP1 and FFP2 masks are available with or without an exhalation valve while FFP3 masks always have a valve. The FFP2 and FFP3 provide a proper fit around the mouth and are highly effective against aerosols\(^6^6\).

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Masks with exhalation valves are not recommended for use in dentistry as the exhaled air is not filtered, so, posing a risk for the patient to get infected from the health care professional, considering the latter to be asymptomatic\(^5^9\). The Health and Safety Executive evaluated the protection afforded by different types of masks against influenza bio aerosols and suggested the use of class FFP3 disposable respirators in aerosol generating procedures. It was clarified that regular surgical masks will not provide protection against aerosols\(^6^6\).

It has been suggested to wear a surgical mask in all situations where there is contact between the patient and other people less than 2 m away and for more than 15 min. Wear an FFP2 or FFP3 mask in procedures with a risk of aerosol droplet production. If not available, use a surgical mask with a face shield\(^6^6\). Qian et al.\(^7^0\) concluded that N95 respirators were highly effective in filtering microbial particles when they were tightly adapted to the shape of the face. The manufacturer’s instructions must be followed to make the best use of any respirator\(^7^1\).

On comparing the different respirators to certify their performance, it was concluded that China KN95, AS/NZ P2, Korea 1st Class, and Japan DS FF1Rs are equivalent to respirators such as US NIOSH N95 and European FFP2, in order to have an effective filtration against bio-aerosols (non-oil based particles)\(^7^2\).

The WHO\(^7^3\) has recommended the use of a particulate respirator at least as protective as a US National Institute for Occupational Safety and Health (NIOSH)-certified N95, European Union (EU) standard FFP2, or equivalent, when performing aerosol-generating procedures such as tracheal intubation, non-invasive ventilation, tracheostomy, cardiopulmonary resuscitation, manual ventilation before intubation, and bronchoscopy. Though dental procedures were not mentioned anywhere, but as we all know, aerosols are generated in various dental procedures. The most significant difference between reusable elastomeric respirators

The effectivity of FFP2 and FFP3 against bio-aerosols (non-oil based particles) - Table 3

<table>
<thead>
<tr>
<th>Classification</th>
<th>Efficiency (BFP)</th>
<th>Efficiency (PFE)</th>
<th>Delta P</th>
</tr>
</thead>
<tbody>
<tr>
<td>FFP1</td>
<td>0-1%</td>
<td>0-1%</td>
<td>≤ 0.5</td>
</tr>
<tr>
<td>FFP2</td>
<td>1-2%</td>
<td>2-3%</td>
<td>≤ 0.5</td>
</tr>
<tr>
<td>FFP3</td>
<td>2-3%</td>
<td>3-5%</td>
<td>≤ 0.5</td>
</tr>
</tbody>
</table>

...
and disposable FFRs is that reusable respirators must be maintained and inspected after each use, including cleaning and disinfection of the elastomeric components such as face piece valves, valve covers, and straps[82-83]. Elastomeric respirators are equipped with replaceable filters. Some replaceable filters are cartridge style in which the filtration media is housed inside of a cartridge. Others consist of flexible, disc or pan cake-style filters, in which the filter media are not housed within a cartridge body[84,85]. The general public should not use these to avoid the shortage as they are in critical supply[86]. Only healthcare workers should be able to use them.

The Virustatic shield is the only face-covering available that has a protective Viruferrin coating tested in the Italian laboratory which is one of the few in the world qualified to carry out the work, as it is certified to Biological Safety Level BSL3, according to Virustatic[87]. The coating creates a protective shield over human cells in the respiratory tract preventing the virus entering. In hosts that are already infected, it will stop the virus from multiplying as stated by UK biotech firm Virustatic Ltd, the firm which has developed this coating. Viruferrin contains lactoferrin, a naturally occurring protein which is an important part of the human innate immune system[88].

This is going to be a particularly important development for the mankind in the midst of this global health crisis. Although more studies and research on the human beings is required to assess whether Viruferrin can be used in treatment of COVID 19 or not considering its presence amongst us, one should take appropriate precautionary measures, while examining and carrying out treatment procedures on patients. Viruferrin contains lactoferrin, a naturally occurring protein which is an important part of the human innate immune system[88].

As it is clear by now that the patients and dental care providers are at a high risk of getting infection. By the very own nature, dental procedures have a high risk of exposure because of proximity to face with dental patients, salivary and blood contamination along with the generation of aerosols[89] because of the use of high-speed instruments. The virus remains suspended in the dental operatory resulting in the airborne transmission of COVID-19[90]. It can settle on the surfaces in the clinical area increasing the chances of cross contamination.

There are only a few alternatives to aerosol generating procedures and so the only solution to it is the proper usage of face masks, PPEs along with the protocols for cross contamination control[92-93].

Learning to co-exist during the pandemic is the new normal and considering its presence amongst us, one should take appropriate precautionary measures, while examining and carrying out treatment procedures on patients. Masks should be properly worn, depending on their type and individual fit and following the manufacturer's instructions as well as other cross-infection control measures must be employed. In case of unavailability of soap and water, use of hand sanitizer with 60% ethanol or isopropanol is recommended.

CONCLUSION

The authors declare that they have no competing interests.

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