COVID-19 APPROPRIATE BEHAVIOUR — WHY DO WE DO WHAT WE DO?

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Nonpharmaceutical Interventions (NPIs) are actions that people and communities can take to help slow the spread of diseases. These measures aim to reduce transmission, thereby delaying the timing and reducing the size of the epidemic peak, and buying time for preparations in the healthcare system. During the current COVID-19 pandemic, the NPIs are in place, and invariably, every citizen has been practising appropriate behaviours such as hand washing with soaps—solid or liquid, using appropriate mask, maintaining social distancing, etc. However, majority of the populations are not aware of why and how such practices help. This paper sheds light on the scientific and historical context of such COVID-19 appropriate behaviours.

Keywords: COVID-19, SARS-CoV-2, nonpharmaceutical interventions, quarantine, isolation.

Introduction

Coronavirus (COVID-19) is a contagious disease caused by a newly discovered coronavirus SARS-CoV-2 (Severe Acute Respiratory Syndrome Coronavirus 2). Most individuals infected with this virus will experience mild to moderate respiratory illness and recuperate without requiring special treatment. However, older people and those with underlying medical problems like cardiovascular disease, diabetes, chronic respiratory disease, and cancer are more likely to develop severe illness. This virus is widely postulated to have originated from animals implicating zoonotic transmission and is well supported by genomic comparative analysis between the human SARS-CoV-2 sequence and beta-CoV RaTG13 of bats (Rhinolophusaffinis) with high homology of 96 per cent (Cascella, et al., 2020). Further, human-to-human transmission results from exposure to infectious respiratory fluids containing the virus. As the world grapples to contain COVID-19, efforts are being made from every possible dimension ranging from Nonpharmaceutical interventions (NPIs) like Covid appropriate behaviours to pharmaceutical measures like drugs and vaccinations.

Non-pharmaceutical Interventions

Non-pharmaceutical Interventions (NPIs) are actions that people and communities can take to help slow the spread of diseases like COVID-19. NPIs are also known as community mitigation strategies. Because this pandemic caused by coronavirus is new, the human population has little or no immunity against it. This allows the virus to spread quickly from person to person worldwide. During a pandemic as this, a vaccine or a therapeutic drug is not immediately available for treatment; hence, personal NPIs and community NPIs become some of the most important ways individuals can protect themselves and others until herd immunity is achieved. NPIs are broadly divided into two:

(i) Personal NPIs are everyday preventive actions undertaken by individuals, apart from pharmaceutical interventions such as getting vaccinated and taking medicines to help keep ourselves and others from getting and spreading respiratory illnesses. Preventive measures like staying home when sick or when exposed to a family or household member who is infected go a long way in helping individuals and stopping transmission.

(ii) Community NPIs are policies and strategies, apart from pharmaceutical interventions such as vaccination and medical treatment delivery methods, that organizations and communities put into place to help slow the spread of illness during an infectious disease outbreak. Closures of child care centres, schools, universities, places of worship, banning sporting events, concerts, festivals, conferences, and other settings that attract a large conglomeration of people are some of the other community NPIs.

During this COVID-19 pandemic, the NPIs are in place, and invariably, every citizen has been practising appropriate behaviours such as hand-washing with soaps—solid or liquid, using appropriate mask, maintaining social distancing, etc. Such practices are not random ideas or norms set up by the whims and fancies of a set of authorities, organisations, or governments but are based on science and scientific findings. That said, majority of the populations, including the educated lot, are not aware of why and how such practices help. This paper sheds light on the scientific and historical context of the practice of social distancing, quarantine measures for suspected and infected individuals, wearing masks, and hand hygiene.

Social Distancing

Social distancing or physical distancing means keeping a safe distance between ourselves and others who are not from our household in outdoor settings and indoor settings. Social distancing can prevent contact and droplet transmission. Transmission of SARS-CoV-2 can occur through direct, indirect, or close contact with infected people through secretions such as saliva and respiratory secretions or their respiratory droplets, which are expelled when an infected person coughs, sneezes, talks, or sings. These secretions are widely classified based on their size. For example, respiratory droplets are more than 5 μm in diameter, whereas droplets less than 5 μm in diameter are referred to as droplet nuclei or aerosols. Respiratory droplet transmission can occur when a person is in close contact (within 1 metre) with an infected person who has respiratory symptoms (e.g., coughing or sneezing) or who is talking or singing; in these circumstances, respiratory droplets that carry the virus can reach the mouth, nose or eyes of a susceptible person and can result in infection.

Studies have acknowledged that both infected people with symptoms and those without symptoms are equally likely to spread the infection. In such a scenario, we do not know who is infected and who is not; it is best advised to stay at a considerable distance from people of another household (Centers for Disease Control, 2020). So, what distance is safe? How far is far enough to limit the spread? The math to arrive at the calculation for social distancing is somewhat complex and challenging as it depends on many variable influencing factors. There is no absolute answer for this problem. But four key factors must be considered (Ciric, 2020).

(a) **Respiratory droplets:** When we breathe, talk, cough, and sneeze, thousands of droplets are expelled from our mouth and nose. However, the size and the number of droplets are different and become essential for studies. The larger droplets contain more virus particles, and the higher the number of droplets, the higher the virus particles. Also, larger droplets settle more quickly because of gravity. Smaller droplets, carrying fewer particles, can remain suspended in the air for hours. The number and proportion of droplets released by the person vary depending on the activity that he/she indulges in. A cough produces more droplets overall, and a more significant proportion of them are larger. Breathing produces fewer droplets overall, and the droplets are also generally smaller. The speed with which the droplets leave our mouth and nose also influences how far they travel—sneeze droplets travel furthest.

(b) **Viral load:** Viral load refers to the number of copies of the virus in a sample. The number of virus copies in the respiratory samples of COVID-19 patients can vary from a few thousand to hundreds of billions per millilitre. The viral load varies from one person to another and depends on the patient's stage of the illness. Knowing the viral load in respiratory droplets allows us to calculate how many virus particles people may be exposed to and whether this might be enough for them to become infected.

(c) **Infectious dose:** The infectious dose is the number of copies of the virus that our body needs to be exposed to develop an infection. When it comes to calculating a safe distance, the closer we are to an infected person, the more likely we are to be exposed to the infectious dose by breathing in virus-laden droplets. The infectious dose for influenza strains varies from thousands to millions of copies. We do not yet know this number for SARS-CoV-2. Further research on the virus and comparisons to other viruses will help to hone this number. In any case, we can be sure that the infectious dose will vary between different people.

(d) **The environment:** Whether we are indoors or outdoors, in school, at work, on public transport, or in the supermarket, the flow of air, ventilation, temperature, and humidity all these circumstances will influence what happens to respiratory droplets.

These factors are not absolute but will give us a fair idea for calculation. A study funded by WHO across 16 countries and six continents, with no randomised controlled trials and 44 relevant comparative studies in health-care and non-health-care settings (n=25 697 patients) found that transmission of viruses was lower with the physical distancing of 1 metre or more, compared with a distance of less than 1 metre; protection was increased as the distance was lengthened. The ideal distance was found at two metres but becomes practically non-implementable at many smaller infrastructural settings finding it challenging to accommodate even a few people (Chu, et al., 2020). Change in relative and absolute risk with increasing distance is provided in Figure 1.

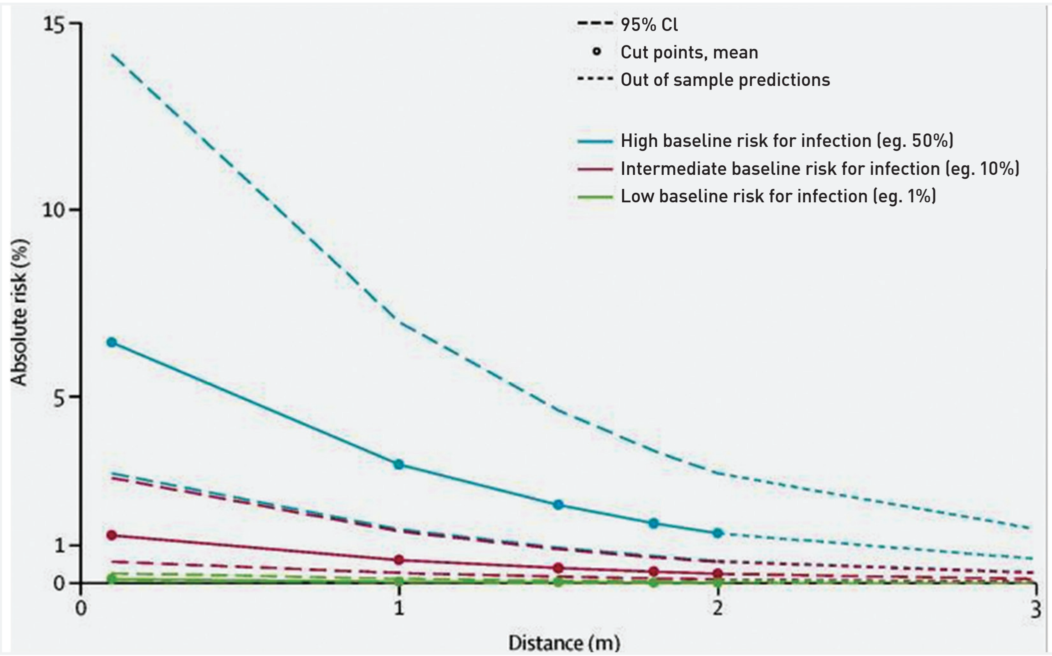

Fig. 1. Change in relative risk with increasing distance and absolute risk with increasing distance [Reproduced from: Physical distancing, face masks, and eye protection to prevent person-to-person transmission of SARS-CoV-2 and COVID-19: a systematic review and meta-analysis (Chu et al., 2020)]

Quarantine/ Self Isolation

The term 'quarantine' is derived from the Italian number *quaranta*, or 40, and the practice originated in 1347-1348 when the 'Black Plague' was sweeping across Europe. Venice founded the first quarantine island, Lazzaretto Vecchio, Santa Maria di Nazareth Island, and became the first city to close its ports to incoming ships to slow the spread of disease. When a successive wave of the plague hit in 1485, the same Italian city required all vessels coming from infected ports to be detained for 40 days. For COVID-19, health officials recommend that people in a city or region with a high number of positive cases or who have come in contact with infected individuals should go into 14 days of self-quarantine.

But what is the science behind 14 days? Why not 6, 10, or even 20 days? The answer comes down to the virus' incubation period, i.e., the time between exposure to the virus to the time when symptoms begin to show. Incubation periods vary from virus to virus (Fig. 2). People also start to develop symptoms at different rates. Health agencies like WHO and CDC (Centers for Disease Control) use data on a virus's incubation period to set their guidelines for quarantine periods. SARS-CoV-2 most commonly has an average incubation period of five days. In addition, about 97 per cent of people who contract the virus will show symptoms within 11 days. That means most people who have been infected with the novel coronavirus will likely show symptoms within 11 days. By setting 14 days for the self-quarantine period, officials allow extra time for people to be certain they have not been infected and cannot spread the virus to others (breakthroughs.com). Social distancing and self-isolation measures must be started as close to the time of disease onset as possible and sustained throughout the peak of disease trajectory in local communities to be most effective. In recent years, these NPI measures have been effective in reducing the impact of H1N1 and containing the 2003 outbreak of SARS-CoV.

Masks

Reducing the transmission of COVID-19 requires two factors: limiting contacts of infected individuals via physical distancing and other measures and reducing the transmission probability per contact. Mask wearing reduces transmissibility per contact by reducing transmission of infected respiratory particles in laboratory and clinical contexts, public settings. Masks create a

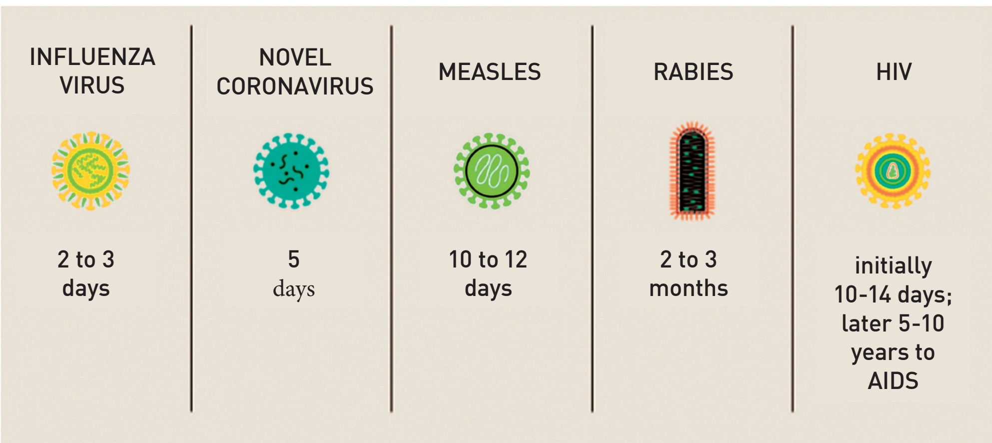

Fig. 2. The incubation period of various viruses

physical barrier that catches these droplets and prevents them from spreading as far into the surrounding air as they usually would. Masks can be used to protect healthy persons or prevent onward transmission (source control) because they can prevent larger expelled droplets from evaporating into smaller droplets that can travel farther (Bai, 2020). Facemasks reduce aerosol exposure by combining the filtering action of the fabric and the seal between the mask and the face. The filtration efficiency of the fabric depends on a variety of factors: the structure and composition of the fabric and the size, velocity, shape, and physical properties of the particles to which it is exposed (Davies, et al., 2013). Although any material may provide a physical barrier to an infection, if, as a mask, it does not fit well around the nose and mouth, or the material freely allows infectious aerosols to pass through it, then it will be of little benefit. Masks become even more critical because a significant proportion of people who get COVID-19 either do not exhibit symptoms or there is a delay before symptoms show up. The use of face coverings can help limit the spread of the disease by these asymptomatic and pre-symptomatic individuals. The virus itself is only about 0.1 µm in diameter. However, because viruses do not leave the body independently, a mask does not need to block particles that small size to be effective. Masks block particles a little larger than 1 micrometre. Pathogen-transporting droplets and aerosols range from about 0.2 µm to hundreds of micrometres across. As a reference, it may be mentioned that an average human hair has a diameter of about 80 µm (Peeples, 2020).

1. How to test the efficiency of the mask?

Determining face mask efficiency is a complex topic that is still under the active field of research. This is made even more complex in the case of COVID-19 because the infection pathways are not yet fully understood and are further complicated by many other factors such as route of transmission, correct fit, and usage of masks and environmental variables. Recently, Fischer, et al. (2020) have come out with a low-cost measurement of face masks efficiency for filtering expelled droplets during speech, cough, and sneezing. A schematic and demonstration image of their experiment is reproduced in Figure 3. In brief, an operator wears a face mask and speaks or coughs or sneezes in the direction of an expanded laser beam inside a dark enclosure. Droplets that propagate through the laser beam scatter light, which is recorded with a cellphone camera. Analysis of the videos is performed with the simple algorithm 'Mathmathica' (Wolfram Research) and is used to count the droplets in the videos. Other methods to evaluate efficiency include air sampling techniques like forcing aerosol particles through different masks and calculating their efficiency. Viruses or bacteria will behave predominately in the air as a result of their physical characteristics rather than their biological properties; that is, virus particles will travel in the air in the same manner as particles of equivalent size and therefore become easy to study and corroborate (Davies et al., 2013).

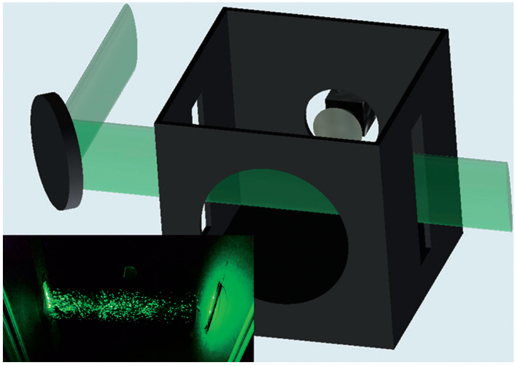

Fig. 3. Schematic image of the experimental setup. A laser beam is expanded vertically by a cylindrical lens and shined through slits in the enclosure. The camera is located at the back of the box, with a hole for the speaker in the front. The inset shows scattering for water particles from a spray bottle with the front of the box removed. [Reproduced from: Low-cost measurement of face mask efficacy for filtering expelled droplets during the speech (Fischer et al., 2020)]

2. Categories of masks

There are broadly three types of masks in use. They are briefly discussed below.

(i) *N95 respirators*

An N95 respirator is a respiratory protective device designed to achieve a very close facial fit and efficient filtration of airborne particles. The edges of the respirator are designed to form a seal around the nose and mouth. N95 respirators can protect against smaller respiratory droplets. These respirators made by different companies have different filtration efficiencies for the most penetrating particle size (0.1 to 0.3 microns), but all were at least 95 per cent efficient at that size for NaCl particles. Above the most penetrating particle size, the filtration efficiency increases with size; it reaches approximately 99.5 per cent or higher at about 0.75 microns (Qian, et al., 1998). N95 respirators have two benefits over other masks like plain fabric or surgical masks; they are more than 95 per cent effective in removing 0.3 µm molecules (less than the 5 µm size of broad droplets produced through speech, coughing, and sneezing that commonly spread influenza) and are checked to ensure contagious droplets and contaminants do not leak across the mask (Dhivyadharshini, Somasundaram and Brundha, 2020). Wearing a loose-fitting respirator will not offer the same protection to the wearer as a poor seal may allow small particles to get inside the mask through the sides.

(ii) *Medical Masks*

Medical masks (also known as surgical masks) are composed of 3 layers of synthetic nonwoven materials, configured to have filtration layers sandwiched in the middle. These are available in different thicknesses. Medical masks may not be as efficient as N95 respirators because they do not filter out smaller aerosol particles as small as 0.3 µm. Apart from this, another disadvantage is that air leakage also occurs through the sides of the mask as we inhale. Although much less is known about the exact efficiency of surgical masks, in a review of observational studies, an international research team estimates that surgical masks are 67 per cent effective in protecting the wearer (Peeples, 2020).

(iii) *Homemade masks*

Several household materials can be used for making household masks and are found to have the capacity to block bacterial and viral aerosols. Even a cotton T-shirt can block half of the inhaled aerosols and almost 80 per cent of exhaled aerosols measuring 2 µm across. Once we get to aerosols of 4–5 µm, almost any fabric can block more than 80 per cent in both directions.

Multiple layers of fabric have been found to be more effective, and the tighter the weave, the better. Another study has found that masks with layers of different materials—such as cotton and silk, could catch aerosols more efficiently than those made from a single material (Peeples, 2020). However, when compared to other masks, homemade masks should only be considered as a last resort to prevent droplet transmission from infected individuals, but it would be better than no protection (Davies et al., 2013).

Hand-hygiene and Fomites

Fomites consist of surfaces or objects that can become contaminated with pathogenic microorganisms and serve as vehicles in transmission. During and after suffering from COVID-19, SARS-CoV-2 viruses are shed in large numbers by respiratory secretions. Fomites become contaminated with the virus by direct contact by hands of the infected person, contact with the aerosolized virus (large droplet spread) generated via talking, sneezing, coughing, or vomiting, or contact with the airborne virus that settles after disturbance of a contaminated fomite (i.e., shaking a contaminated blanket). These fomites containing the SARS-CoV-2 virus can be found on surfaces for hours or even days, depending on environmental conditions, and can be detected of their presence by RT-PCR testing. Once a fomite is contaminated, the transfer of infectious virus may readily occur between inanimate and animate objects or vice versa, and between two separate fomites (if brought together) (Boone and Gerba, 2007). While we do not have the numbers for SARS-CoV-2, a study recovered 3 to 1,800 PFU of rhinovirus from the fingertips of volunteers who handled contaminated doorknobs or faucets (Pancic, Carpentier and Came, 1980). A plaque-forming unit (PFU) is a measure used in virology to describe the number of virus particles capable of forming plaques per unit volume. Using coliphage PRD-1 as a model, Rusin, et al. (2002) demonstrated that 65 per cent of the virus could be transferred to uncontaminated hands. Virus survival on fomites is influenced by intrinsic factors, including fomite properties or virus characteristics, and extrinsic factors, including environmental temperature, humidity, etc. If viruses remain viable on surfaces long enough to come in contact with a host, the virus may only need to be present in small numbers to infect the host. The longest survival (6 days) of severe acute respiratory syndrome coronavirus (SARS-CoV) on surfaces was done by placing a very large initial virus titer sample (107 infectious virus particles) on the surface being tested. However, a real-life situation is better represented in the work of Dowell, et al. (2004) in which a viable virus was found on fomites for only a few hours.

After contact of fomite with the host is achieved, viruses can gain entry into the host systems through portals of entry or contact with the mouth, nasopharynx, and eyes. Hands are the main pathways of germ transmission between fomites and individuals. Hand-hygiene is, therefore, the most critical measure to avoid the transmission of harmful germs. We discuss in brief here the role of soaps and sanitizers in hand-hygiene. It is also a piece of common sense advice that people should try to touch surfaces, if unavoidable, with their non-dominant hands rather than dominant hands. We have trained for years unconsciously that the dominant hand comes in contact with the mouth, nasopharynx, and eyes. Hence transmission can be avoided to some extent by touching surfaces with a non-dominant hand.

Hand Washing

Soap is a common word for what chemists call 'amphiphiles'. These are molecules that have dual nature. One end of the molecule is attracted to water and repelled by fats and proteins. The other side of the molecule is attracted to fats and is repelled by water (Fig. 4). It is this dual-nature chemical construction that makes soap so effective. Any conventional soap that we buy consists of a mixture of these amphiphiles. And they all do the same thing.

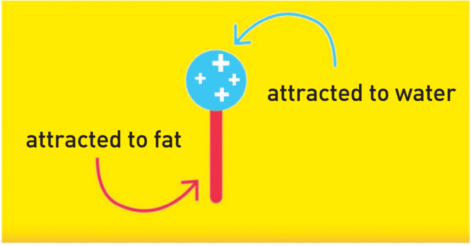

Fig. 4. The dual nature of soap molecules

Coronaviruses, simply put, are like a bag made out of oil/ fat: bits of genetic information—encoded by RNA—surrounded by a coat of fat and protein. The soap takes care of the virus much like it takes care of the oil in the water. One side of the soap molecule (the one that is attracted to fat and repelled by water) buries its way into the virus's fat and protein shell. Fortunately, the chemical bonds holding the virus together are not very strong, so this intrusion is enough to break the virus's coat. Soap pulls the virus apart and makes them soluble in water, and they disintegrate. And when we wash with water, the leftover innocuous bits and pieces of virus get flushed down the drain. Soap will also wash away bacteria and other viruses that may be a bit tougher than coronavirus and harder to disintegrate. But it takes a little time to happen, and that is why we need to spend at least 20 seconds washing our hands. First off, our skin is wrinkly, and it takes time for the soap to penetrate into all the tiny folds and demolish the viruses that lurk within. Then the soap needs a few moments to do its chemical work. We need a bit of time for all the soap to interact back and forth with the virus particle. Twenty seconds should do the trick just fine.

Hand Sanitisation

To understand how hand sanitizers work, let us understand the structure and make-up of viruses. Viruses are relatively simple structural, infectious agents with a minimum of two structural components. First, they contain genetic material, such as DNA or RNA. The genetic materials inside viruses are either single-stranded (ssDNA or ssRNA) or double-stranded (dsDNA or dsRNA). The strands are also either positively or negatively sensed. In order to protect and encapsulate the genetic material, all viruses also contain a protein coat called a capsid (Fig. 5). The novel coronavirus, for instance, is an enveloped virus surrounded by a fat layer/protein layer as mentioned earlier.

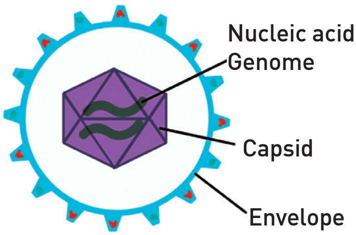

Fig. 5. Structure of Virus

There are two broad categories of hand sanitizers. (1) alcohol-based hand sanitizers (ABHS) and (2) non-alcohol-based hand sanitizers (NABHS).

1. Ingredients and Action of ABHS

Hand sanitizer preparations containing alcohol can include ethanol, isopropyl alcohol, n-propanol, or a combination of these, water, as well as humectants and excipients. Solutions containing alcohols between 60 per cent and 95 per cent in the volume are most prevalent and effective. Water is necessary to increase the penetration of alcohol. That is why 100 per cent pure alcohol-based sanitizers are less effective than solutions containing 60-95 per cent alcohols. Humectants are included to prevent skin dehydration as in commercial lotions, and excipients help stabilize the product and prolong the time needed for the evaporation of alcohol, thereby increasing its biocidal activity.

Alcohol kills viruses through a simple chemical process known as denaturation. Denaturation is the term used for any change in the three-dimensional structure of a protein that renders it incapable of performing its assigned function. Denaturation occurs when alcohol molecules bond with the fat membrane encasing a virus or bacteria cell. As the fat membrane is broken down, the inside of the cell—including all of its critical components—becomes exposed. Given that all these components are necessary for the viral life cycle (e.g., attachment, penetration, biosynthesis, maturation, lysis), and thus critical for its ability to transmit to another host, it can be presumed that altering the structure or function of any of the components as mentioned earlier or dissolving will typically render the virus ineffective. These components start to dissolve, and the cell quickly dies.

Ethanols have a broader and more potent virucidal activity than propanols. A high concentration of ethanol has shown to be highly effective against enveloped viruses and thus is effective against the majority of clinically relevant viruses. It is also interesting to note that adding acids to ethanol solutions can increase its efficacy against viruses more resistant to ethanol alone.

2. Ingredients and Action of NABHS

The most common primary active ingredient of NABHS is benzalkonium chloride (BC), quaternary ammonium, and is a commonly used disinfectant. The lipid envelope of either bacteria or viruses is a critical structure for BC's effectiveness. The cationic 'head group' of BC is progressively adsorbed to the negatively charged phosphate heads of phospholipids in the lipid bilayer, and as a result, increase in concentration. The consistent increase of BC concentration results in reduced fluidity of the membrane and thus the creation of hydrophilic gaps in the membrane. In addition, the alkyl chain 'tail' component of BC further perturbs and disrupts the membrane bilayer by permeating the barrier and disrupting its physical and biochemical properties. Protein function is subsequently disturbed, and the combination of the effects mentioned above results in the solubilization of the bilayer constituents into BC/phospholipid micelles. BC also interrupts intercellular targets and compromises the conformational behaviour of DNA.

However, when comparing hand washing and hand sanitization, the former is recommended (CDC, 2020, 2021). Such endorsement of hand washing stems from various factors, such as eliminating a broader spectrum of pathogens and chemicals and removing bioburden on soiled hands. Hand sanitizers work by killing germs on your hands, while washing your hands with soap and water removes germs from your hands. Hand washing will remove all types of germs from your hands, but hand sanitizers are not able to kill all types of germs or remove harmful chemicals like pesticides and heavy metals.

Conclusion

We have discussed the science behind COVID-19 appropriate behaviours such as social distancing, quarantine/self-isolation, masking, hand hygiene and fomites, hand-sanitization, and how practising such NPIs can significantly reduce the spread of SARS-CoV-2 and buy scientists and the government more time to tackle the pandemic. However, practising NPIs is not the ultimate solution. We will still need effective vaccines and drugs to subdue the virus completely and end the pandemic.

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