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Chemistry behind Preventing the Spreading of COVID 19 - A Study

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ABSTRACT

Coronavirus disease (COVID-19), an infectious disease caused by newly discovered Coronavirus, has only been around for a few months and so scientists are putting concerted effort to know much about it and more is being learned every day. General perception is that Coronavirus can live on surfaces for up to nine days and survives in the air for a few hours. It spreads primarily through droplets containing virus particles of saliva or discharge of fluids from nose when an infected person coughs or sneezes and the virus sometimes land on surfaces. Hands touch many surfaces and get contaminated with viruses. The hands can transfer the virus to eyes, nose or mouth to enter body and make sick, and results rapid spread of infectious Coronavirus. Keeping the hands germ free either through the use of hand sanitizers soap or water and social, physical distancing are perceived to be some of the important answers to preventing the spread of the virus. Still, questions are arising in minds, what should we do in our homes to keep away from it and how can we take the fight directly to the virus? In this study we are going to discuss the methods used and the chemistry behind preventing and containing the spread of Coronavirus. The study is based on the literature available on line. The SARS-CoV-2 is a novel virus which needs more and more research to eradicate it and save the life from pandemic.

Keywords : Coronavirus, Prevention, Spreading, Hand Sanitizers, Surface, Transmission, Safety

I. INTRODUCTION

Coronavirus disease (COVID-19) is an infectious disease caused by newly discovered Coronavirus. The Covid-19 virus referred to as 'novel coronavirus' and this type of coronavirus hasn't been seen in humans before. Coronaviruses are actually a big virus family, and some of them cause types of what we call the common cold. SARS-CoV-2 is the particular member of this family that is causing this outbreak. For most, the disease is mild, but some people die.

Since it's a novel virus, there is no specific vaccine available that can treat it. However, according to the WHO, many of the symptoms can be treated and therefore, the treatment is based on the patient's clinical condition. As there is no established treatment for it and it has killed over a million people globally. To discover a new vaccine, though sophisticated technology is on hand, it will tend to take a time. The immediate step to be taken is to contain the pandemic from spreading rapidly.

Several studies and publications reveal that he coronavirus that causes COVID-19 may spread through the air in tiny particles and that tiny airborne particles infect people exhale during normal breathing and speech. An infected person spews thousands of tiny droplets which contain the virus through cough or sneeze every time they do. The SARS-CoV-2 can survive in the air for up to three hours. Closed space causes more harm. Keeping the windows open and the open air can remove and disperse the droplets and reduce the amount of virus in the air which will reduce the risk of infection for others. Wearing surgical masks and more physical distancing can also cut down on the amount of airborne virus.

Outside of the body, there are ways for us to destroy the virus and reduce our own chances of contracting it. To understand how these work, it's useful to know about the structure of this particular virus. SARS-CoV-2 is a type of enveloped virus. This just means it's got an outside layer around its genetic material. The outside layer is made of fat molecules and is one of the possible targets for destroying the virus. We can also target proteins in this layer, or even the genetic material itself.

II. EXPLANATION

SURVIVAL ON DIFFERENT SURFACES

Two recent studies have investigated how long coronaviruses survive on different surfaces. The research looked at a number of different viruses including SARS-CoV-2 – the coronavirus that has caused COVID-19. And it found that the survival times varied according to the type of surface. The virus survived for longest on stainless steel and plastic for up to nine days. The shortest survival times of one day was for paper and cardboard. Figure-1 shows the table of time surviving in air and on surfaces.

The number of hours Coronaviruses survive in air and on different surfaces

	SARS-CoV-2	SARS-CoV-1	MERS-CoV-1	HCoV
Air	3	3	-	-
Paper	-	96	-	-
Cardboard	24	8	-	-
Wood	-	96	-	-
Copper	4	8	-	-
Glass	-	96	-	120
Ceramic	-	-	-	120
Plastic	>72	216	48	144
Steel	48	48	48	120

SARS-CoV-2: causing COVID-19
SARS-CoV-1: caused SARS outbreak in 2003
MERS-CoV-1: caaused MERS outbreak in 2012
HCoV: other human coronaviruses
-: no data available

Figure-1: Shows the table of time surviving in air and on surfaces.

The amount of virus particles during this time does reduce, but it's worrying that the particles can last for days rather than hours or minutes on a surface. It is further evaluated in detail the estimated decay rates of coronavirus (SARS-CoV-2) as per the Bayesian regression model.

III. EVALUATION OF DECAY RATES ON MATERIALS

A pandemic causing novel human coronavirus is named Severe Acute Respiratory Syndrome Coronavirus - 2 (SARS-CoV-2) (formerly called HCoV-19) emerged in Wuhan, China, in late 2019. The aerosol and surface stability of SARS-CoV-2 and compared it with SARS-CoV-1, the most closely related human coronavirus is analysed.

The stability of SARS-CoV-2 and SARS-CoV-1 in aerosols and on various surfaces and estimated their decay rates are evaluated using a Bayesian regression model. The data consisted of 10 experimental conditions involving two viruses (SARS-CoV-2 and SARS-CoV-1) in five environmental conditions namely aerosols, plastic, stainless steel, copper, and cardboard. The SARS-CoV-2 remained viable in aerosols throughout the 3 hour duration of experiment , with a reduction in infectious titer from

$10^{3.5}$ to $10^{2.7}$ $TCID_{50}$ per liter of air. This reduction was similar to that observed with SARS-CoV-1, from $10^{4.3}$ to $10^{3.5}$ $TCID_{50}$ per millilitre. All the experimental measurements are reported as means across three replicates as Figure-2 (A) (B) and (C).

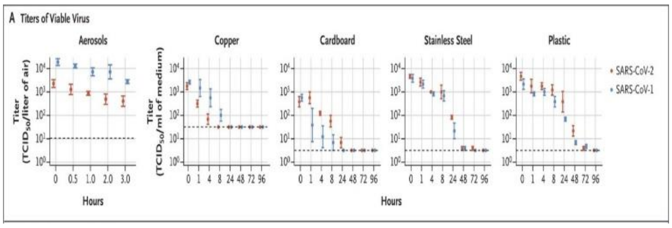

Figure – 2: A - Titer of Viable Virus

As shown in Panel A, the titer of aerosolized viable virus is expressed in 50% tissue-culture infectious dose ($TCID_{50}$) per liter of air. Viruses were applied to copper, cardboard, stainless steel, and plastic maintained at 21 to 23°C and 40% relative humidity over 7 days. The titer of viable virus is expressed as $TCID_{50}$ per milliliter of collection medium. All samples were quantified by end-point titration on Vero E6 cells. Plots show the means and standard errors (I bars) across three replicates.

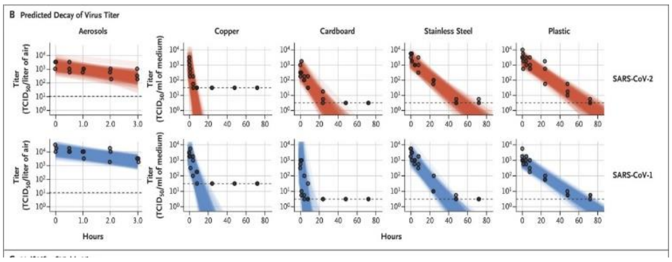

Figure – 2: B – Predicted Decay Time of Virus Titer

As shown in Panel B, regression plots indicate the predicted decay of virus titer over time; the titer is plotted on a logarithmic scale. Points show measured titers and are slightly jittered (i.e., their horizontal positions are modified by a small random amount to reduce overlap) along the time axis to avoid over plotting. Lines are random draws from the joint posterior distribution of the exponential decay rate (negative of the slope) and intercept (initial virus titer) to show the range of possible decay patterns for each experimental condition. There were 150 lines per panel, including 50 lines from each plotted replicate.

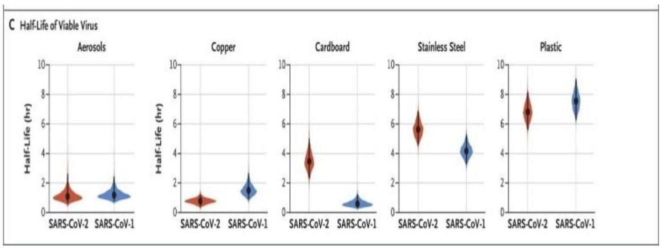

Figure – 2:C – Half-Life of Viable Virus of SARS COV-2 SARS COV-1

As shown in Panel C, violin plots indicate posterior distribution for the half-life of viable virus based on the estimated exponential decay rates of the virus titer. The dots indicate the posterior median estimates, and the black lines indicate a 95% credible interval. Experimental conditions are ordered according to the posterior median half-life of SARS-CoV-2. The dashed lines indicate the limit of detection, which was $3.33\times10^{0.5}$ $TCID_{50}$ per liter of air for aerosols, $10^{0.5}$ $TCID_{50}$ per milliliter of medium for plastic, steel, and cardboard, and $10^{1.5}$ $TCID_{50}$ per milliliter of medium for copper.

The estimated decay rates as per the Bayesian regression model, the estimated median half-life of SARS-CoV-2 was approximately 5.6 hours on stainless steel and 6.8 hours on plastic (Figure -2 C). Estimated differences in the half-lives of the two viruses were small except for those on cardboard (Figure - 2C).

Individual replicate data were noticeably "noisier" (i.e., there was more variation in the experiment, resulting in a larger standard error) for cardboard than for other surfaces (Fig. S1 through S5), so we advise caution in interpreting this result.

The results indicate that aerosol and fomite (objects or materials which are likely to carry infection such as clothes, utensils and furniture) transmission of SARS-CoV-2 is plausible, since the virus can remain viable and infectious in aerosols for hours and on surfaces up to days depending on the inoculums shed.

These findings echo those with SARS-CoV-1, in which these forms of transmission were associated with nosocomial spread and super-spreading events and they provide information for pandemic mitigation efforts.

IV. TO STUDY IF THE VIRUS REMAIN ON MATERIAL AND TRANSMISSION IS PLAUSIBLE

1. WASH YOUR HANDS FOR 20 SECONDS

As per the studies the Coronavirus is considered to be similar to Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS) – related corona virus and so it should not be that difficult of a microorganism to kill. It is therefore, soap and water and alcohol based hand sanitizers can kill it. A mantra 'Wash your hands for 20 seconds' has been recited most oft-repeated to adopt and practice to contain the spread and destroy Coronavirus. Soap contains molecules called surfactants, which have two ends: one end dissolves really well in fats, while the other end dissolves really well in water. When these molecules come into contact with the fatty outside layer of SARS-CoV-2, they dissolve it and tear the virus apart. The World Health Organisation has issued guidelines and recommended the use of hand sanitizers to arrest the virus spread for the assured safety, effectiveness and security of human. Health specialists have been emphasising upon the importance of keeping the hands germ free either through the use of soap or hand sanitizers. Sanitizing hands will kill viruses present on hands. The mantra 'Wash your hands for 20 seconds' could be effectively followed with cleaning and sanitizing substances and contain the spread.

2. SOAP AND WATER

Soap and water are your first line of defence to remove the virus from surfaces. Soap interferes with the fats in the virus shell and lifts the virus from surfaces and this is then rinsed off by water. All types of soap contain these surfactant molecules, so it really doesn't matter which type you use. Some soap contains additional antibacterial ingredients, but these are active against bacteria, so they don't affect the virus. The soaps that contain surfactant molecules still do the job. To explore deeper into the chemistry of soaps and surfactants, the Chronicle Flask is a great explainer of the history of soap, as sanitizers, bleaches and how it works. Soap and water isn't just good for the hands but also effective at cleaning surfaces, too and no need to rush out and buy any fancy surface cleaners. Hence, the best choice is to wash hands with soap and hot water in the absence of hand sanitizer. It must be remembered that once hands are washed, dry them thoroughly by using towels, paper or warm air dryer. The figure - 3 showS how the hand sanitizer soap is weakening the coronavirus (The coronavirus is named for the protein spikes embedded in its surface).

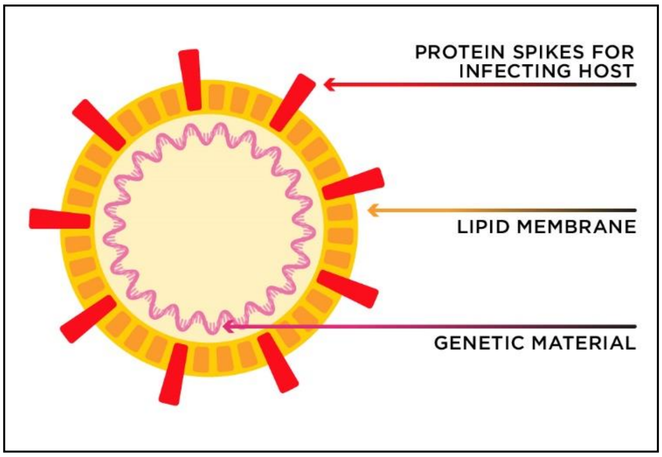

Figure – 3: Weakening the Corona With Soap

Image adapted from: Jonatahan Corum and Ferris Jabr/The New York Times.

It may be noted Coronaviruses get their name from the 'corona' surrounding the virus—specifically, the protein spikes embedded in its surface. The spikes, which are responsible for infecting the host, are anchored into a membrane. The membrane is the 'shell' of the virus. This is the coronavirus's weak point.

Soap molecules have two chemically distinct parts: a hydrophilic (water-loving) 'head' and a hydrophobic (water-hating) 'tail'. The head helps the soap mix with water, while the tail can interact with other hydrophobic molecules like lipids. The Lipids are a class of biological molecules that includes oils and fats. The coronavirus's membrane is mostly made up of lipid molecules. They are held together by weak chemical interactions between individual molecules. The hydrophobic (water-hating) 'tails' of soap molecules can break interactions between lipid molecules in the coronavirus membrane. Hence, soaps will all work against the novel coronavirus., when it comes down to the chemistry.

3. HAND SANITISERS

Soap is great where there is an easy access to water and a sink. But in the absence of accessibility to water and a sink, the right choice is hand sanitizers. In the supermarkets, banks, etc., the hand sanitizers assume importance. As the concerns about coronavirus are growing, the demand for hand sanitizers is high. The alcohol-based sanitisers are effective against many types of virus, including SARS-CoV-2. It is used to kill SARS-CoV-2too.

The main ingredient in hand sanitizers is ethanol, the isopropyl alcohol in surgical spirit. But its concentration in the sanitiser is very important. To kill the virus effectively, it has to be over 90 per cent to 99 per cent. There are two types of alcohol-based and non-alcohol-based hand sanitisers. The non-alcohol-based hand sanitizers are proved to be less effective against viruses whereas alcohol-based very effective. The Centers for Disease Control and Prevention (CDC), a national public health institute of the United States, recommends the hand sanitizers need to contain at least 60 per cent alcohol, if soap and water are not available, to avoid spreading germs to others. It also indicates that the hand sanitizers without 60 to 95 per cent alcohol may not work equally well for many types of germs and merely reduce the growth of germs rather than killing them outright. It also recommends that a minimum concentration of 70% alcohol is needed to clean the surfaces.

According to a joint study by scientists from Germany and Switzerland the new coronavirus is more sensitive to alcohol than the two other deadly coronaviruses – Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS)and can be killed almost completely by ethanol concentrations as low as 30 per cent. The World Health Organization recommends alcohol-based hand sanitisers to remove the novel coronavirus if there is no soap on hand.

Alcohol-based hand sanitisers are thought to work by preventing the proteins of microbes—including bacteria and some viruses including corona—from functioning normally. Hand sanitisers with alcohol content are effective against the lipid shell surrounding the coronavirus. The alcohol molecules damage the structure of virus proteins, destroying the virus. They also dissolve the fatty outside layer of the virus.

Hand washing with soap and water and alcohol-based hand sanitizers are the best options for destroying any traces of virus on your hands. For hard surfaces, there are also other options which work in similar ways against the virus.

4. SURGICAL SPIRIT

Surgical spirit is mostly made up of the alcohol ethanol. Ethanol has been shown to kill coronaviruses in as little as 30 seconds. Like bleach, the alcohol destroys the protein and ribonucleic acid (RNA) that the virus is made up of. Moisten a cloth with some neat surgical spirit and rub it over a surface. This will evaporate and you will not need to wipe it off. Target your home's high-touch surfaces.

5. SURFACE WIPES

The active ingredient in surface wipes in an antiseptic –- usually benzalkonium chloride. The wipes work by physically removing germs through the pressure you apply when you use them, and the germs then attach to the wipe.

They also leave a layer of the antiseptic on the surface that works to kill germs. The antiseptic works well on bacteria as well as on coronaviruses that infect mice and dogs – but it seems to make no difference to the spread of human coronavirus. Antiseptics work by disrupting the fats in pathogen cells, but SARS-CoV-2 does not contain many fats. So far, there is no evidence that antiseptics can kill human coronaviruses.

6. BLEACH

The active ingredient in bleach is Sodium Hypochlorite. It is very effective at killing the virus. Make sure you leave the bleach to work for 10-15 minutes then give the surface a wipe with a clean cloth. The bleach works by destroying the protein and what's known as the ribonucleic acid (RNA) of the virus – this is the substance that gives the blueprint for making more virus particles when infected.

Bleach solution is very effective at cleaning hard surfaces. The Centers for Disease Control and Prevention (CDC) explain how to make a 0.1% solution from household bleach on their website. Bleach reacts with and destroys virus proteins and the virus genetic material. It's important to spray it on the surface and then leave it to act for around 10 minutes for the maximum effect.

It's also very important not to mix bleach with other cleaners. There's no need to anyway, as it does a very effective job on its own. And if you do, there's the risk of the cleaner reacting with the bleach and generating toxic chlorine gas. We're trying to kill the virus here, not us. A minimum of 0.5% hydrogen peroxide solution is also effective against viruses. It works in a similar manner to chlorine bleaches, reacting with and destroying virus proteins and genetic material. Similarly, it should be left to act for up to ten minutes. It's also a good idea not to mix it with other cleaners, particularly those containing vinegar. Vinegar and hydrogen peroxide makes corrosive peracetic acid, and while this is also used in some cleaners, it's not a good idea to mix it up like this us.

Really, the bleach and peroxide options are overkill. Soap and water will do an effective job on any surface you can clean with them. Soap's less hazardous to work with, too, and can be easily used to regularly clean surfaces you touch frequently.

V. SAFETY ISSUES

1. Fire Hazard Issues

Hand sanitizer was originally developed for use in healthcare environments, but is now widely used in many settings. Many people carry hand sanitizer with them at all times so they can keep their hands clean even when they don't have access to water. Most hand sanitizer products contain a high volume of alcohol, which is the reason for hand sanitizer fire hazard concerns. Alcohol-based hand sanitizers are classified as Class I Flammable Liquid substances, which means they have a flash point of less than 100 degrees Fahrenheit. Hand sanitizer vapors can be flammable. In the event that hand sanitizer combusts, carbon monoxide and carbon dioxide can form. Personnel involved in extinguishing hand sanitizer fires, should wear respiratory protection.

2. Other Safety- Related Issues

Safety precautions needs to be taken while the sanitizer on hand. There are regular reports about accidental ingestion and dermal absorption of alcohol-based sanitizers used for hand hygiene. There was acute, severe alcohol intoxication resulting from accidental ingestion of an unknown quantity of alcohol-based hand rub resulting in the unconsciousness of an adult male patient which primarily metabolized by an alcohol dehydrogenase in the liver to acetone. Some times alcohol based sanitizer causes symptoms and signs of alcohol intoxication include headache, dizziness, lack of coordination, hypoglycaemia, abdominal pain, nausea, vomit-ing, and haematemesis. It may also lead the signs of severe toxicity include respiratory depression, hypotension, and coma. Further, there is a risk of habitual use of hand sanitizer if it is not needed.

3. OTHERS

Chlorinisation can be useful to disinfect surfaces and spraying such substances can be harmful to clothes or mucous membranes such as eyes, mouth, nose, etc., but the sanitizers need to be used under appropriate recommendations.

VI. CONCLUSION

India has a huge population that could be affected if the novel coronavirus is not prevented and contained. It creeps in very slowly and then explodes suddenly, like the exponential growth as it seen with most of the developed countries. The responsibility of preventing and containing the coronavirus that hasn't been seen in humans before, lies with the scientists, administrators and the people as well. The people are advised with do's and don'ts. The radical spread of virus could be arrested by adopting the sanitization of hands and the surroundings. Use of masks, sanitizers such as Soap, water and alcohol based sanitizers, physical and social distancing are some of the important steps to fight the coronavirus directly. Dust off the bleach and open windows to let in the air flow freely rather than closed doors. Follow the preventive measures, save yourself and save others life from pandemic. During this crisis of uncertain times 'Stay home and safe.'

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