COVID-19 and the Approaches to Handle the Clusters in Sri Lanka

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Abstract: The COVID-19 pandemic is the most crucial world health disaster of the 21st century, caused by the SARS-CoV-2 virus. As of 3rd, February, 2021, the global death toll surpassed 3 million amid more than 110 million cases. This virus mainly spreads from person to person, primarily from the nose or mouth. People can catch the COVID-19 if they breathe or swallow these droplets from an infected person. These droplets are comparatively heavy, do not travel far and quickly drop to the ground. The Real time RT–PCR is one of the most broadly used laboratory techniques for detecting the COVID-19 virus. Wearing the masks, maintaining social distancing between people and washing the hands with soap or sanitizer frequently are some of the efficient methods that reduce the spread of this disease. Government of Sri Lanka has implemented several measures to curb the spread of infection. Important features of management of the COVID-19 in Sri Lanka are extensive contact tracing, early intervention, timely isolation of all the possible contacts and providing organized quarantine facilities for contacts. Several vaccines have been proven to be efficacious in preventing the Covid-19 infection. Uncertainty of the diverse COVID 19 vaccines in practice and their global access have been a challenge still. The COVID-19 pandemic has brought a spirit of collaboration to industries and people and creates us a chance to reimagine what's possible moving forward.

Keywords: *COVID-19, immunocompromised, RT–PCR, SARS-CoV-2, Vaccine.*

1. INTRODUCTION

The COVID-19 pandemic is considered as the most crucial world health disaster of the 21st century and the greatest challenge to mankind since World War II. It has put forth a remarkable adverse effect on the day-to-day life of entire world doubtlessly. The World Health Organization (WHO) has declared that this new coronavirus spread is pandemic (Liu *et al*., 2020). Officially, as of 20th January 2023 Covid-19 deaths toll globally was reported as 680,4491 (WHO, 2023). Corona virus disease 2019 (COVID-19) is instigated by a new virus which was initially identified in Wuhan, China in December, 2019. On February 11, 2020, the WHO organization announced an official name for the disease that was causing the 2019 novel coronavirus outbreak. The name given to this disease was coronavirus disease 2019 and it is abbreviated as COVID-19. In COVID-19, 'CO' stands for corona. 'VI' for virus and 'D' for disease. Previously this disease was denoted as "2019 novel coronavirus" or "2019 - nCoV" (Liu *et al*., 2020).

1.1. Understanding of Corona virus

These Corona viruses are huge family of viruses which causes diseases in both animals and humans. The most recently discovered disease causing coronavirus is COVID-19. The coronavirus family causes illness ranging from the common cold to more severe disease such as Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS). They socialize in animals and some can be transmitted between animals and human. This novel virus and disease were unfamiliar before the outbreak began in Wuhan, China, in December, 2019. COVID-19 is now considered as a pandemic affecting many countries globally causing severe losses not only to the human life but also causes far reaching economic consequences to the global economy (Morens *et al*., 2020).

1.2. Emergence of SARS-CoV-2

A coronavirus is a one of common viruses which causes an infection in the human organs such as nose, sinuses, or upper throat (REF). In early 2020, after the December 2019 outbreak in

China, the WHO identified SARS-CoV-2 as a new type of coronavirus. The outbreak quickly spread around the world (Morens *et al*., 2020).

1.3. Modes of COVID-19 transmission

COVID-19 virus mainly spreads from person to person. Mostly, the disease spreads primarily from the nose or mouth, which are expelled when persons with COVID-19 cough, sneeze, or speak. These droplets are comparatively heavy, do not travel far and quickly drop to the ground. People can catch the COVID-19 if they breathe or swallow these droplets from an infected person (Rahman *et al.*, 2020). This is why it's important for people to stay at least 1 meter away from others. People get infection by touching these droplets land on objects and surfaces such as tables, doorknobs, handrails and switches. After that it enters the human body when we touch our eyes, nose or mouth. Therefore, it is important to wash our hands regularly with soap and water or clean with alcohol-based hand rub (Khan *et al*., 2020). SARS-CoV-2 can also be transmitted through air borne route, but the extent to which this mode of transmission has contributed to the pandemic is controversial.

1.4. Origin of COVID-19

COVID-19 is a new disease caused by a novel coronavirus that has not earlier been identified in human. Animal Coronaviruses rarely infect the people and then spread from person to person. Human infections were reported with two earlier Coronaviruses such as MERS-CoV and SARS-CoV. SARS-CoV-2 virus is also a beta coronavirus like MERS-CoV and SARS-CoV. All these three viruses have their origin in bats (Morens *et al*., 2020). On December 31, China alerted the WHO about the cases of unusual pneumonia in Wuhan. They believed COVID-19 was originated from a seafood market where wildlife was sold illegally for the food purpose. The WHO declared the virus pandemic on March 11 2020. The virus could spread from an infected animal to human through illegally trafficked pangolins, prized in Asia for food and medicine. Scientists have suspected either bats or snakes as possible sources of this virus. However, the exact source of the virus has not been identified yet (Cennimo, 2020).

1.5. Surface survival time of the COVID-19 virus

A study reveals that SARS-CoV-2 can last for several hours on different types of surfaces. COVID-19 can survive up to 72 hours on plastic and stainless steel and less than 4 hours & 24 hours on copper and cardboard respectively. The most important thing to know about coronavirus on surface is that they can easily be cleaned with common household disinfectants that would kill the virus. Therefore, it is suggested to always clean our hands with an alcohol-based hand rub or wash them with soap and water. We should avoid touching our eyes, mouth, or nose and disinfect the surfaces frequently with suitable surface disinfectants (Von Doremalen *et al*., 2020).

1.6. Symptoms of COVID-19

Common symptoms developed during the infection includes fever, dry cough, sore throat and problems related to breathing. In severe cases, it can cause pneumonia, multiple organ failure and death. The incubation period is approximately 1 to 14 days. It can be transmitted before symptoms appear. Therefore, there is high risk of transmission in the community. Infected patients may not show any symptoms while they have the virus in their body (Cennimo *et al*; 2020). Severity of the illness may vary among individuals. Most people will develop mild to moderate illness during the infection and recover without getting admitted in the hospital. More rarely, the infection can lead to death. Older people and those with underlying medical conditions (such as high blood pressure, heart problems or diabetes) are highly susceptible for COVID-19 (Zhou *et al*., 2020).

Most common symptoms of COVID-19 are fever, dry cough, and tiredness. And less common symptoms are aches and pains, sore throat, diarrhea, conjunctivitis, headache, loss of taste or smell, discoloration of fingers or toes

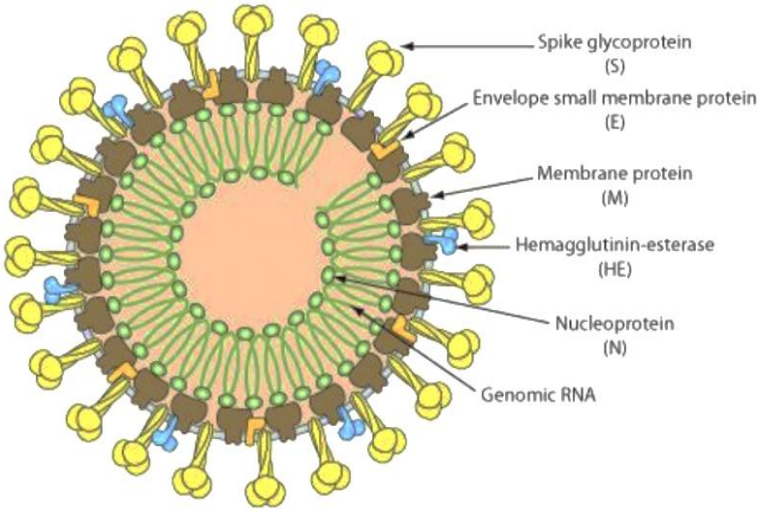

Figure 1: Structure of SARS-CoV-2 (COVID-19) virus (Mousavizadeh *et al*., 2020)

and rash on skin. Other symptoms that shows under serious conditions are problems in breathing or shortness of breath, chest pain or pressure and loss of speech or movement. The virus can lead to pneumonia, respiratory failure, heart problems such as myocarditis, stress cardiomyopathy and liver problems such as increased level of liver enzymes (alanine aminotransferase and aspartate aminotransferase) which cause liver damage during illness, or death. Most of the COVID-19 problems may be caused by a condition recognized as cytokine release syndrome. This condition happens due to an infection that triggers human immune system to flood human blood stream with inflammatory proteins known as cytokines. It can kill tissues and damage the human organs (Cascella *et al*., 2020, Yu *et al*., 2021).

Some COVID-19 infected people can rarely present with some abnormal symptoms are face- One side of the person's face is numb or drooping, arms- One arm weak or numb and Speech - they can't speak clearly and can't repeat the sentence. If a person has serious symptoms, he/she is advised to seek medical attention immediately. Government advice public to always call before visiting the doctor or health facility. People with mild symptoms or healthy could manage their symptoms at their home. Approximately, 5 to 6 days will take for a person to show symptoms when someone is infected with the virus, but it can take up to 14 days. Some people who are affected by COVID-19 also have dangerous blood clot in their legs, lungs and arteries, where there are cases that show no symptoms at all (Cennimo, 2020).

1.7. Corona virus risk factors

Any person can be infected by COVID-19, but most infections are mild. The older people have higher risk of severe illness. People with chronic kidney disease, chronic obstructive pulmonary disease (COPD), weakened immune system because of an organ transplantation, obesity, serious heart conditions such as heart failure or coronary artery disease, sickle cell disease and type 2 diabetes have higher chances of getting serious illness. Conditions that could lead to severe COVID-19 illness are moderate to severe asthma, disease that affects the blood vessels and blood flow to the brain, cystic fibrosis, high blood pressure, a weakened immune system because of a blood or bone marrow transplantation, HIV or patients who are on medications like corticosteroids, dementia, liver disease, pregnancy,damaged or scarred lungs tissue (pulmonary fibrosis), smoking, thalassemia and type 1 diabetes (Jiang *et al*., 2020, Zhou *et al*., 2020).

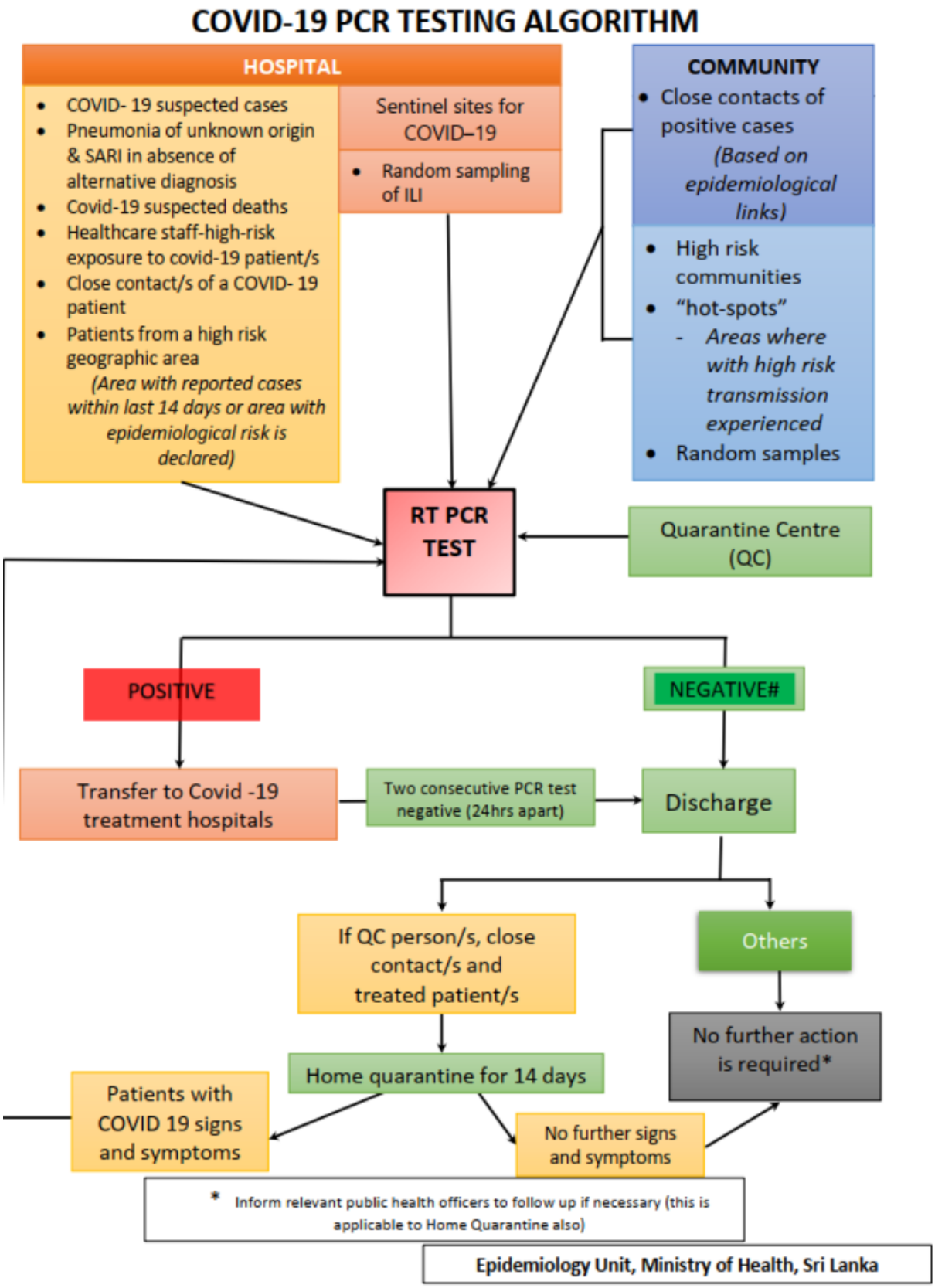

Figure 2: COVID19 PCR testing Algorithm followed by the Sri Lankan Health care system

1.8. Structure of SARS-CoV-2(COVID-19) virus

SARS-CoV-2 viruses are spherical enveloped non- segmented positive sense RNA virus with diameter ranging between 65 nm to 125 nm. The viral genome is packed inside the helical shaped Nuclepcapsid (N) protein localized in the endoplasmic - reticulum - Golgi region to facilitate the replication cycle and the cellular response of host cell to viral entry. Further virus is surround by an envelope. Viral envelopes are associated with three structural proteins including the membrane (M) glycoprotein, the envelope (E) glycoprotein and spike (S) glycoprotein. SARS-COV-2 also encodes an envelope associated with hemaggulutinin-esterase (HE) protein (Astuti et al., 2020, Mousavizadeh *et al*., 2020).

The envelope (E) protein is the smallest protein in the SARS-CoV-2 structure and it plays a vital role in the viral reproduction and maturation. The membrane (M) protein forms the structure which determines the shape of the virus. The spike (S) protein is a trans-membrane protein that is 150kD in size and makes up the outer part of the virus and gives the crown like appearance by protruding the surface of the virus. The spike made up into three segments including a large ecto domain, a single - pass transmembrane anchor and a short intracellular tail. The ecto domain consists of a receptor binding subunit (S1) and a membrane fusion subunit (S2). Under the electron microscope, the spike protein appears as clove shaped trimmer with three S1 head and trimeric S2 stalk and facilitates the virus envelope to bind with the host cell by attraction with angiotensin - converting enzyme 2 (ACE2), which expressed in lower respiratory tract cells (Astuti *et al*., 2020, Mousavizadeh *et al*, 2020).

1.9. Coronavirus and its genetic material

A virus has a tiny package of genetic material such as deoxyribonucleic acid (DNA) or ribonucleic acid (RNA) enclosed by a molecular envelope. Coronavirus (SARS-CoV-2) only contains RNA, so that it depends on infiltrating healthy cells to multiply and survive. Once inside the cell, the virus uses its own genetic code RNA. In the case of the COVID-19 virus, RNA of the virus functions to take control and reprogram the cells turning them into virus-making factories (Cascella *et al*., 2020).

2. DETECTION OF COVID-19

2.1. Detection of COVID-19 by using PCR technique

This Real time RT–PCR method is a nuclear-derived technique for identifying the occurrence of specific genetic material in any pathogen, including a virus. Initially, this method used radioactive isotope markers for identifying targeted genetic materials, but subsequent refining has run to the replacement of isotopic labelling with special markers, most commonly fluorescent dyes. This technique helps scientists to find the results instantly while the process is still ongoing, but conventional RT–PCR only gives results at the end of the process (Vabdenberg *et al*., 2020).

The Real time RT–PCR is one of the most broadly used laboratory techniques for detecting the COVID-19 virus. This real time RT–PCR method is used for diagnosing other diseases, such as Ebola virus and Zika virus in many countries and the same technique is also used for the COVID-19 virus. The real time RT–PCR method is highly sensitive and specific and can deliver a trustworthy diagnosis in as little as 3 hours, though laboratories take on average between 6 & 8 hours. Compared to other virus detection methods, real time RT–PCR is ominously faster and has a lower chance for contamination or errors, as the entire procedure can be carried out within a closed tube. This is the most accurate method available for the detection of the COVID-19 virus, at present. Anyhow, real time RT–PCR cannot be used to detect past infections, which is important for understanding the development and spread of the virus, as viruses are only present in the body for a specific window of time. Other methods are necessary to detect, track and study the past infections, particularly those which may have

developed and spread without symptoms (Emery *et al*., 2004).

RT–PCR is a variation of PCR, or polymerase chain reaction. The two techniques use the same process except that RT–PCR has an added step of reverse transcription of RNA to DNA, or RT, to allow amplification to take place. This means PCR is used for pathogens, such as viruses and bacteria that already contain DNA for amplification, while RT–PCR is used for those containing RNA that needs to be transcribed to DNA for amplification. Both techniques can be performed in 'real time', which means results are visible almost immediately, while when used 'conventionally', results are only visible at the end of the reaction. PCR is one of the most widely used diagnostic tests for detecting pathogens, including viruses, that cause diseases such as Ebola, African swine fever and hand-foot- mouth disease. Since the COVID-19 virus only contains RNA, real time or conventional RT–PCR is used to detect it (Emery *et al*., 2004).

2.1.1. The role of Real-Time PCR in COVID-19 testing and diagnosis

The swab sample is collected with plastic or wire shafts by using only synthetic fiber swabs. First minitip swab with a stretchy shaft over the nostril parallel to the palate (not upward) is inserted until resistance is come across or the distance is equal to that from the ear to the nostril of the patient, including contact with the nasopharynx. Swab should extent the depth equal to distance from nostrils to outside opening of the ear (minimum 1cm (0.5 inch) inside the nostril). It is needed to gently rub and roll the swab then leave swab in place for some seconds to absorb secretion. After that swab should be gradually removed while spinning it (WHO, 2020). The sample is treated with lot of chemical solutions to remove substances such as proteins and fats that allows the sample to have RNA only (Green *et al*., 2020). This extracted RNA is a blend of the person's own genetic material and, if the viral RNA is present, the RNA is reverse transcribed to DNA by a specific enzyme called reverse transcriptase. After that, scientists add additional short fragments of DNA those are matching to specific parts of the transcribed viral DNA. If the virus is present in a sample, these fragments bind themselves with target region of the viral DNA. Some of the added genetic sequences are used for synthesizing DNA strands in the amplification process, while the others are used to building the DNA and adding marker labels to the strands, these are then used to detect the virus (Ward *et al*., 2020).

Then, the mixture is placed in a RT–PCR machine. The machine cycles over temperatures that heat and cool the mixture to activate specific chemical reactions that create new, matching copies of the target sections of viral DNA. To copying the target sections of viral DNA, the cycle is repeated over and over. Each cycle doubles the earlier number: two copies convert four, four copies convert eight, and so on. A standard real time RT–PCR set-up usually generates 35 billion new copies of viral DNA from each strand of the virus present in the sample (Jewerth, 2020). The new copies of the viral DNA sections joined with marker label and produced the fluorescence, which is measured by the computer which presented in real time on the screen. The computer tracks the quantity of fluorescence in the sample after each cycle. When a certain level of fluorescence is exceeded, this confirms the presence of the virus. Scientists would also count how many cycles it takes to attain this level in order to find out the severity of the infection: the fewer the cycles, the more severe the viral infection (Jewerth, 2020).

2.2. Serological test for COVID-19 detection

Covid-19 antibody testing is a blood test, that could determine if a person had a past infection with SARS-COV-2, but this antibody test can't determine whether the person is currently infected with the COVID-19 virus. Antibodies are proteins that produced by the immune system in response to an infection. This identifies foreign substances in the body and help to fight against the infections and diseases.

After the infection with COVID-19 virus, infected person's body will start to develop the antibody to fight against that specific covid-19 virus, but it can take two or three weeks to develop enough antibodies to be detected in an antibody test, so it's important that the person should not be tested at the early stage of infection (Baraniuk, 2020).

It is a common question whether a COVID-19 positive antibody test resulted person is immune against the disease. However, the scientists still don't know what ideal immune system responses to COVID-19 (Baraniuk, 2020).

.Antibodies may play an important role in providing certain amount of immunity against the COVID-19 viruses, but at present there is no enough evidences to decide how these antibodies last and whether past infection of COVID-19 virus protects human from getting another infection. Because, antibodies may disappear from the person's body over time. After a period of time, these antibodies might form the physiology of the person vulnerable to COVID-19 virus attack (Baraniuk, 2020).

An ideal antibody test is like Cinderella's glass slipper- just one foot can match throughout the testing of COVID-19, the tiny antigen protein of the SARS-CoV-2 virus are coated on to a plate. Then they are exposed to a blood sample from an infected person and after that an enzyme and some chemical reagents are jointly applied. If the precise antibodies for the SARS-CoV-2 virus are present within the blood sample, they are going to bind with the viral antigen protein on the plate. Then the enzyme sticks with the antibody which subsequently activates the chemical reagent and causing a colour change giving off a luminescence that indicates a positive result (Baraniuk, 2020).

The following viral antigens are used to detect antibodies for SARS-CoV-2:

- **Spike protein** - Spike proteins (S proteins) are unique, mushroom shaped surface proteins that bind host cells and mediate virus entry. Each monomer of 'S' protein contains two subunits, S_1 and S_2, which facilitate attachment and membrane fusion respectively. S_1 and S_2 subunits could also be used individually or combined as antigens for serology testing (Zabiegala *et al*., 2023).
- **Nucleocapsid** - The nucleocapsid protein (N protein) may be a basic RNA binding protein that plays structural role in infection. In complex with genomic RNA, N protein forms the viral capsid of SARS-CoV-2 and it plays number of additional roles in the pathogenesis (Wu *et al*., 2023).
- **Receptor Binding Protein (RBP)** - Represents the protein of the S_1 protein that binds angiotensin - converting enzyme 2 (ACE2), the human receptor form SARS-CoV-2. Accurate interpretation of antibody testing depends up on antigen specificity and it plays a strong role in the immunity. IgM, IgG, IgA and total antibody count are the first targets of COVID-19 serology test (Silva *et al*., 2022).
- **IgM** - This is one of the first set of antibodies produced during infection. Antigen binding site of IgM is not highly specific, but it allows simultaneous binding of multiple antigen and it is rapidly cleared from the blood stream during primary infection. Although IgM is the largest antibody by size, its abundance in the blood is only about 10% of total antibody count (Silva *et al*., 2022).
- **lgG** - This is often the tiniest and most abundantly circulating antibody. It will be approximately 80% of total antibody count and is primarily found in the serum. IgG typically appears later in the infection when mature B cells receive signal to switch from production of IgM to IgG. During the secondary immune reaction, it involves in direct neutralization of microbes and targeting of microbes for immune cell - mediated processes. This is most specific and a key player in establishing post-infection immunity (Silva *et al*., 2022).

- **IgA** - This is primarily responsible for protecting mucosal surfaces and found in serum, mucosal secretions, saliva, tears, sweat and breast milk (Baraniuk, 2020).

2.2.1. Antibody test that may detect certain types of antibodies related to the COVID-19 viruses.

- **Binding antibodies** - These are widely available antibody test to detect whether the person has developed any antibodies in response to a COVID-19 infection. But they don't show how effective the person immune response (Krammer, 2020).
- **Neutralizing antibodies** - These are not widely available, a new one and more sensitive test that detects a subgroup of antibodies which may inactivate the virus. This test is done after a person tests positive for binding antibodies and also through this can be found out how effective antibodies are in blocking the virus to help protect from another COVID-19 infection (Krammer, 2020).

Antibody test for COVID-19 can be carried out in different kind of individuals who has past infection with SARS-CoV-2 but not tested before, a person who had positive results for COVID-19 infection in the past and need to undergo a medical examination in the clinic and in a covid19 recovered person who wants to donate plasma. (Baraniuk, 2020, Vandenberg *et al*., 2020). Risk of this antibody test is that primarily the accuracy of this test is questionable because this test is done immediately after the infection. Further, quality of the test is also questionable because some different manufacturers rush to put antibody test in the market with little oversight. COVID-19 antibody testing may sometimes lead to false positive result that the person doesn't have antibody but the test result would be positive. False negative result means a person has the antibodies of COVID-19 but it cannot be detected by the test (Baraniuk, 2020, Vandenberg *et al*., 2020).

2.3. Rapid Antigen Test (RAT)

Rapid antigen test (RAT) kit technology has become a crucial alternative tool for COVID-19 clinical diagnosis. Additionally, it might be suitable for usage in an emergency. RAT is based on immunochromatography, which uses nitrocellulose membranes with antibodies spotted on them that interact with particular antigens from patient samples. Either manually or with the aid of an immunofluorescence machine reader, the antigen-antibody interaction can be seen. The nucleocapsid protein of the virus is frequently the target analyte for the diagnosis of COVID-19. The swab sample is collected with plastic or wire shafts, after that mix the swab into the extraction buffer and squeeze the extraction tube to place 2 drops of the liquid into the specimen well on the test strip and wait for about 30 minutes. If coloured line appears in both control line and test line then test result is positive, if coloured line appears in the control line only then test result is negative or there is no coloured line in the control line then the RAT kit is inappropriate for the test. Benefit of the RAT test is more easily accessible to people, quick and inexpensive. Additionally, it makes it possible to implement proper infection control measures earlier, which is crucial during a pandemic. The World Health Organization has advised that a RAT kit must achieve a minimum performance criterion of at least 80% sensitivity and 97% specificity when compared to an NAAT reference test to be utilized for SARS-CoV-2 diagnosis. (Khandker *et al*., 2021, Osterman *et al*., 2022)

3. VACCINE DEVELOPMENT FOR COVID-19

Over 60 million people have recovered from the disease worldwide. The scientists faced so many difficulties to develop the vaccine for COVID-19. This is because, the COVID-19 viruses are highly adaptive to rapid reproduction and also, they have the ability to change their genetic information (mutate) with each new generation. Therefore, COVID-19 viruses can potentially develop resistance to whatever drug or vaccines

scientists develop. However, scientists developed several vaccines for COVID-19. These vaccines are all designed to teach the body's immune system to safely recognize and block the virus that causes COVID-19 (WHO, 2020).

Vaccines are developed with different technologies for COVID-19. Vaccines take the form of the virus that has been inactivated or weakened. Therefore, COVID -19 vaccine will not cause disease, however it can generate an immune response. Protein based vaccines which use harmless fragments of protein shells that mimic the COVID-19 virus, are extracted, purified and injected as a vaccine. For COVID-19 virus, it is common to induce the spike protein to safely generate an immune response (WHO, 2020). In viral vector-based vaccine, the gene which encoded for a COVID-19 virus protein is inserted into a different virus which can serve as a safe virus vector. Therefore, this virus can infect without causing any symptoms and COVID-19 virus protein can be used to safely generate an immune response. In nucleic acid-based vaccines, the nucleic acid coding for the antigen is injected instead of a virus, a protein antigen or a virus expressing the protein. The genetically engineered RNA or DNA is injected to develop an immune response and this is the new technology that has been developed recently (WHO, 2020).

Developing vaccine should undergo through several clinical trials to ensure the safety and efficiency of the output. Basic clinical trials to develop the vaccine:

1. Preclinical studies to test the vaccine in animals for efficacy and safety, including challenge studies.
2. Phase I clinical trial is that vaccine is given to a small group of healthy adult volunteers to ensure the safety.
3. Phase II clinical trials is that vaccine is given to people who have characteristic (such as age and physical health) similar to those whom the new vaccine is intended.
4. Phase III clinical trial is that vaccine is shot to thousands of people and tested for safety and efficacy.
5. Phase IV post marketing surveillance is ongoing studies after the vaccine is approved and licensed to monitor adverse events and to study long term effects of the vaccine in the population.
6. Final one is human challenge studies - Studies in which a vaccine is given followed by the pathogen against which the vaccine is designed to protect. Such trials are uncommon in people as they present considerable ethical challenges (WHO, 2020).

As of 02nd October 2020, there are 42 COVID-19 vaccine candidates in clinical trial, out of these 10 in phase III trials. There are another 151 vaccine candidates in preclinical trial, phase III trial usually needs 3000 or more participants and all top vaccine candidates are for intravascular injection, most vaccines are designed for a two-dose schedule and some are for a single dose schedule (Pancevaki *et al*., 2020, WHO, 2020). The sputnik-v-vaccine, Pfizer /BioNTech and Astra zeneca/oxford vaccines are some vaccines that are in use. Few vaccines have been authorized to date Pfizer/BioNTech's BNT162b2 received temporary authorization from the UK medicines and health care products Regulatory Agency on 2nd of December 2020. Gamaleya Research institute in Moscow developed the Sputnik-v-vaccine that formerly known as Gam-COVID-vac and the sputnik-v-vaccine was approved on 11 August 2020 by ministry of health of Russian federation. But medical experts raised considerable concern about the vaccine's safety and efficacy because, on the date of approval it has not entered phase III clinical trials. A second vaccine in Russia, DpiVac corona has also been granted regulatory approval before entering in to the phase III clinical trials (Craven, 2020).

3.1. Pfizer/BioNTech vaccine

Pfizer/BioNTech would make the most rapid vaccine development for a pandemic in history following all the important stages.. From starting the first trial participants on May 5th to getting approval for emergency use authorization in UK within six months. The vaccine BNT162b2 developed by the Pfizer/BioNTech that claim 95% protection against COVID-19 pandemic that killed more than 1.46 million people and infected 62.8 million (Pancevaki *et al*., 2020)

Besides Pfizer, Moderna Inc, which was one of the first firings to start human clinical trials of its mRNA vaccine on 16th March 2020 has already applied for emergency use license in the US. Serum Institute of India (SII), which is trialing a version of Astra zeneca oxford vaccine is also expected to follow suit within the next two weeks. On 23rd April 2020, Oxford University had started phase I trials of its ChAdOx1 nCoV-19 vaccine. A new type of jab called an RNA vaccine and uses a tiny fragment of the virus genetic code. This begins produces the part of the virus inside the body, which the immune system recognizes as foreign body inside the body and begins to attack. The genetic material is enclosed in a tiny protective bubble of fat to get it in to cells. The exact components of the vaccine have not been made public. This is the first RNA vaccine to be approved for use in human, the virus genetic code will turn it into a vaccine that is injected into the patient. The vaccine enters the cells and tell them to produce the coronavirus spike protein, the body's immune system react, produces antibodies and activates T-cells to destroy cells with the spike protein. If the patient later catches coronavirus, the antibodies and T-cells are triggered to fight against the virus. Pfizer/BioNTech vaccine was started the phase I and II trial on 5th may 2020 and phase III trials started on 28th July 2020. On 12th August 2020 data from early-stage trials shown vaccine elicited robust immune response in participant, on 27th October 2020 complete Phase III enrollment of 43,661 volunteers and on 09th November 2020 interim analysis shown 95% efficacy, on 18th November 2020 they announced that final results shown 95% efficacy and they applied for Emergency Used Authorization (EUA) two days later. Finally, on the 2nd December 2020, the Great Britain becomes the first country in the world to approve the vaccine (Pancevaki *et al*., 2020).

The vaccine is a two-dose scheduled one after the first dose, the vaccine showed more than 52% effective, protection that increase to 95% effective a week after the second dose was administrated. Second shot of this vaccine is given 21 days after the first shot, the second dose being a booster, immunity begins to kick in after the first dose but, reaches its full effect seven days after the second shot. Effectiveness varies little by age, ethnicity and race. On white people 95% effective, on black people 100% effective, on all others including American - Indian, Asians and Pacific islanders 89% effective and on people with underlying conditions 95% effective (Hopkins *et al*; 2020).

Side effects are common but mostly minor including pain from the injection, headache, chills, muscle pain, fatigue and fever. And these are symptoms of the immune system kicking into prepare and can be managed with paracetamol. Pfizer/BioNTech started the vaccination program, which is outside the clinical trial on 08th December 2020. The preferred the first priority for the people who resident in a care home for older adults and their careers, everyone aged 80 and over, front line health and social workers, people aged 75 and over, aged 70 and over and those who are clinically extremely vulnerable, aged 65 and over and people aged 16-64 with underlying health conditions will get the vaccine first. In London Margaret keenan, 90 years old women (former shop clerk) is the first person in the world to get the Pfizer COVID-19 vaccine shot outside of the clinical trial as Britain on 08th December 2020 and William Shakespeare, a 80 years old man was the second person to be given a jab. The two people who got the Pfizer vaccine had a reaction shortly after having the new jab, had treatment and now completely recovered.

Therefore, the medicines and health care products Regulatory Agency said, the people with a history of significant allergic reactions shouldn't have the Pfizer/BioNTech covid jab. The advice applies to those who have had reactions to medicines, food or vaccines. The vaccinated people have had anaphylactoid reactions, which tend to involve a skin rash, breathlessness and sometimes a drop-in blood pressure. And both vaccinated people have history of serious allergies and carry adrenaline pens around with them (Murray, 2020). Two people, out of thousands vaccinated had an allergic reaction which they recovered and such reactions can happen with any vaccine and are treated with drugs such as steroids or adrenaline.

Pfizer/BioNTech plans to monitor patients who were vaccinated for 2 years to learn more about duration because, since it is not clear how long protection might last (Hopkins *et al*; 2020). The Pfizer/BioNTech vaccine should be stored at ultra-freezing temperature (-70°C). Therefore, this vaccine is not suitable for distribution and storage in the developing and underdeveloped countries and also in the rural areas where these ultra-freezing facilities are absent (Hopkins *et al*; 2020).

3.2. Astra zeneca and Oxford University vaccine

Astra zeneca and Oxford University vaccine is developed by British - Swedish pharmaceutical company Astra zeneca and Oxford University. The ChAdOx1 nCoV-19 vaccine is a replicant defective chimpanzee adenovirus vectored vaccine against coronavirus. That expressing the full length of SARS-CoV-2 spike glycoprotein gene (Ramasami *et al*., 2020).

The vaccine of Astra zeneca Oxford that started their phase I trials on 23rd April 2020, on 22nd may 2020 started the enrollment for phase II/III trials, on 20th July 2020 the early- stage trials shown robust immune response, serum institute got nod for phase II/III trials in India on 3rd August 2020, 09th September 2020 phase III halted after the adverse event in UK. On 19th November 2020 phase II trial results shown robust immune response in older adults, and 23rd November 2020 interim analysis shows an average efficacy of 70%. The Astra Zeneca and Oxford University vaccine has shown 70% effective after 14 days that two standard dose which had a gap of 28 days. Interim efficacy results were reported for ongoing trials involving 11,636 participants in the UK and Brazil. Among them, 131 volunteers developed COVID-19, 30 from the group that received the vaccine and 101 from the control group. In UK trials a group of volunteers had received half-dose of the vaccine as the first dose, followed by a standard (full) dose (LD/SD) and another group of volunteers had received two standard doses (SD/SD). Candidate who received low dose followed by a standard dose showed 90% effective, and those who received two standard doses yielded only 62% of efficacy. The average efficacy was 70 % (Punj, 2020). The vaccine causes the 175 serious adverse events. Among them 84 in the vaccine grouped and 91 from the control group. The adverse effects caused by the vaccine, including transverse myelitis occurring 14 days after a ChAdOx1 nCoV-19 booster vaccination, hemolytic anemia in a control recipient, and fever higher than 40°C in a participant. And also, another two additional transverse myelitis cases considered unlikely to be related to the intervention one case 10 days after the first dose of the vaccine and another one 68 days after vaccination and that occurred in control group. The transverse myelitis cases lead to a temporary halt to the trial and all participants have recovered. The common side effects of this vaccine are injection site pain, feeling feverish, muscle ache and headache (Punj, 2020). The vaccine can be stored for long term at ordinary refrigerator temperatures (at 2°C to 8°C), therefore it could be easier for its distribution throughout the world and also it is suitable for developing and underdeveloped countries (Voysey *et al*., 2021). This vaccine is proven to be efficacious in preventing development of COVID-19 illness. The oxford vaccine is being manufactured by Serum Institute of Indian (SII) in Pune, and is in the

phase III clinical trial, named COVISHIELD (Punj, 2020).

3.3. The sputnik-v-vaccine

The sputnik-v-vaccine was developed by Gamaleya National Research Centre of Epidemiology. It doesn't have any side effects. This vaccine contains human adenovirus vector to deliver a gene that codes for the surface protein, spike of the SARS-CoV-2 the virus that causes COVID-19. This is the first vaccine which was made by two different human adenovirus vectors. The two-dose scheme started with a rAd26 vaccine and is followed by a second booster vaccine 21 days later that contain rAd5 spike. In this vaccine, the developers used two different adenoviruses because of the concern that immune responses to the same vector could minimize the impact of the booster (second) shot (Logunov *et al*., 2020). The Russian sputnik-v-vaccine became first in the world to register a COVID-19 vaccine and it was approved by the ministry health of Russian federation. The quick approval of sputnik-v-vaccine was initially criticized as premature because that the vaccine was tested in a small number of people in early stage and also the phase III clinical trial which is the necessary scientific step to prove the vaccine's safety and efficacy in thousands of individuals and was not completed at the time of approval (Burki, 2020).

Phase I/II clinical trials of the vaccine have been completed on 1st August 2020 and all volunteers are feeling well and haven't reported any unwanted side effects. The vaccine induced strong antibody and cellular immune response and not a single participant of current clinical trials got infected with the COVID-19. On 20th August 2020 the sputnik-v-vaccine candidate was tested on 40000 volunteers in Russia, Belarus and also a number of countries such as UAE, India, Venezuela, Egypt and Brazil, they underwent phase III double blind randomized, placebo clinical trial in more than 45 medical centers to confirm clinical efficacy during post approval studies (Balakrishnan, 2020). On 9th September 2020, phase 3 of clinical trials of the sputnik-v-vaccine against the novel coronavirus has commenced in Russia. Sputnik-v- vaccine has shown 92% efficacy in preventing Covid-19 infection. It is advised that the vaccinated people should avoid public places and reduce their intake of medicine and alcohol, which could suppress the immune system, within the first 42 days after the first jab (Burki, 2020, Logunov *et al*., 2020).

3.4. Moderna vaccine

The vaccine moderna on 16th March started their phase I/II trials, on 14th July 2020 the early stage trials shows vaccine help to produce antibodies that can neutralize the novel coronavirus. Moderna vaccine contains synthetic version of mRNA, when the vaccine is injected into the person body that mRNA genetic code starts to produce the copies of fragment of the virus, that fragment in the immune system stimulates the activity to attack the real COVID-19 virus when it tries to invade (Jackson e*t al*., 2020). The moderna vaccine developers announced in September 2020 they completed enrollment of it 30000 person and that 25600 participants had already received two shots. They also ensured the diversity among participants that included 37% from colored communities and 42% from population considered at high risk because they were over 65 or had conditions like diabetes, obesity or heart disease. This is also having two dose schedules; the second shot was given four weeks after the first shot. In moderna's clinical trial at people developed the COVID-19, among them five were vaccinated and other 90 were received the placebo shots of the salt water. In the 95 cases, 11 were severe that all in the placebo group. The 95 cases that included 15 people were 65 or above and 20 people who have Hispanic, Black, Asian or multi-racial. The Moderna developers announced that their vaccine appeared equally safe and effective in all the subgroups (Mahase, 2020). Side effects of the Moderna vaccine at the interim data analysis included pain at the injection site, fatigue, aching muscle and joint, headache,

chills and myalgia (Jackson *et al*., 2020). The moderna vaccine shows the longer shelf life for mRNA-1273 at refrigeration (-4°C) and also at room temperature (up to 12 hours), there for it will be easy to distribute the vaccine and to store in developing, underdeveloped countries and also rural areas (Page, 2020).

3.5. Chinese COVID-19 vaccine

China is racing to develop a covid-19 vaccine and has entered in the third and final stage of clinical trial including Sinovac Biotech vaccine. The developers reported that the last stage trials of the four Chinese vaccines are being conducted in Pakistan, Saudi Arabia, Russia, Indonesia and Brazil and nearly 60000 participants received vaccine by early November 2020. Trials of Sinovac Biotech vaccine in Brazil were briefly halted last week, however it again restarted after the reported death of volunteer and was found to be not linked to the vaccine. These vaccines are already being offered to essential workers as a part of the Emergency program, while one was approved by chineese military in June 2020. It can be stored in a refrigerator at 2°C-8°C. Sinovac was tested in more than 1000 volunteers out of which some only showed minor fatigue (Jones *et al*., 2020).

The vaccine sinovac contains inactivated virus particles which are composed by using killed viral particles to expose the body's immune system to the virus without making serious adverse reactions (Zhang *et al*., 2020). Another Chinese COVID-19 vaccine named sinophram has already been distributed to nearly a million people in China under the controversial emergency programme. Sinophram was registered in the UAE ministry of health and prevention on 09th December 2020, after interim analysis showed 86% efficacy. Sinophram has two competitive divisions that produce vaccine using in activated SARS-CoV-2 one based on Beijing and other in Wuhan, China (Jones *et al*., 2020).

4. EFFECTIVE WAYS TO PROTECT FROM COVID-19

According to the WHO, if a person is a part of the COVID-19 spreading community, the following should be the simple precautions:

1. Maintenance of 1 meter or 6 feet distance from others to reduce the risk of infection when others cough, sneeze and speak.
2. Wearing of mask when we are around the other people or in the crowd of people. Before wearing a mask we need to make sure that our hands are clean. The mask should cover the nose, mouth and chin. When we take off the mask, it should be kept in a clean plastic bag. Used masks shouldn't be in the reach of people who are under the age of 2 and those who have issues in breathing.
3. To make the environment safer, we should avoid close contact with people, avoid indoor gathering.
4. We have to maintain some basic hygienic qualities frequently and thoroughly. We should clean our hands with soap and water or alcohol-based hand sanitizer, avoid touching our eyes, nose and mouth to prevent the spread of virus from our hand to face. When we cough or sneeze, we need to cover the nose and mouth with our bent elbow or tissue. The tissue should be disposed carefully in the bin.
5. Clean and disinfect the surfaces (such as doorknobs, phone screen etc.) which are frequently touched.
6. Before handling the vegetables and fruits, we should clean our hands with soap and water, then wash the fruits and vegetables thoroughly with clean water especially, when eat them raw.
7. When we are doing laundry, we can use detergents or soap, there is no need to use an extra hot water but, before handling the cloths we need to make sure that our hands are clean.

8. Due to the grocery shopping, we must keep at least 1 meter or 6 feet distance from others, avoid touching our face and it would be good to sanitize the handles of the shopping trolleys or baskets and also sanitize the hands after handling and storage of the products.

We are expected to know the full range of the symptoms that caused by COVID-19 virus mainly, fever, dry cough, tiredness, loss of taste and smell, aches and pain, headache, sore throat etc. Patients should stay home and isolate himself or herself, if the symptoms are mild Ex: cough, headache and mild fever until recovery. If we have fever and headache with difficulties in breathing, immediately we need to seek medical attention through our local health authorities (WHO, 2020).

5. COVID-19 PANDEMIC IN SRI LANKA

The COVID-19 pandemic in Sri Lanka is part of the world-wide pandemic spread of corona virus disease caused by SARS-CoV-2 (Wickramarachchi, 2020). In Sri Lanka, first COVID-19 wave began on the 27th January 2020. As of 20th, January 2023, death toll in Sri Lanka is 16,828 amide 671,987 cases and 655,158 people have recovered from the disease. A 44year old Chinese woman from Hubei province who visited Sri Lanka as a tourist was reported as the first COVID-19 patient, and she was admitted to the National Institute of Infection Disease (NIID) and on the10th March 2020, the first local Sri Lankan national tested positive for COVID-19 who was a 52-year-old tourist guide. After this COVID-19 case, Sri Lankan army formed 45 quarantine centers as a preventive measure to handle the COVID-19 situation. Approximately 3500 people have been under quarantine in these centres. Sri Lanka implemented various sequential measures to improve and maintain the social distance such as closure of the schools and education institutes, introducing work from home model to reduce the public gathering and also enforcing a travel ban for international arrivals by closing the airport and ports together. More importantly, Island wide curfew was imposed to minimize the spread and the disease to the entire country. Further, government implemented a strict strategy of detection of COVID-19 cases, identification of people who contact with COVID-19 positive patients, quarantine, travel restrictions and isolation of small villages where the COVID-19 contacted persons were identified. Effective control measures such as spraying disinfectant to destroy the virus in public places was also practiced. The community health team worked hard to conduct the PCR testing to the suspected people and COVID-19 cases were identified (Erandi *et al*., 2020, Jayasena & Chinthaka., 2020).

When one COVID-19 case was confirmed from Polanaruwa who was a soldier from Welisara navy camp, the Welisara navy camp was quarantined immediately. Cluster developed from this navy camp ended up quarantining about 4000 people that includes soldiers and their families. Because of this cluster, a total number of 906 COVID-19 cases were reported (Erandi *et al*., 2020).

Sri Lanka also faced another COVID-19 cluster that originated from the Kandakadu drug Rehabilitation Centre. The first COVID-19 contracted person was identified on the 7th July 2020. This cluster was first discovered when an infected person was confirmed in Colombo's Welikada prison who was transferred there from ‘Kandakadu’ drug rehabilitation camp. This cluster had a link to the one of the groups of drug addicts that were found to be COVID-19 positive in April 2020 (Ministry of Defense, 2020). Sri Lanka that faced second COVID-19 wave which began on the 4th October 2020. This was activated in Minuwangoda when the COVID-19 second wave was reported, where there were 3396 cases with 13 deaths recorded. The study that was carried out by the scientists at the Department of immunology and molecular medicine and allergy of the Sri Jayawardenapura University conducted a whole genomic sequencing of the SARS-CoV-2 virus with the support from Australian government through WHO Sri Lanka, revealed that the COVID-19

virus strain which was active in the second wave in Sri Lanka was different from the strain that circulated due to the first wave. It has B. 1.42 lineage, and this strain was similar with the one that spread in Europe (Sweden /Denmark) (WHO, 2020).

The second wave of the Covid 19 infection in Sri Lanka was first identified when a worker in the Brandix apparel factory in the Minuwangoda area was found to be positive for Covid 19 infection. After this case, government has implemented many preventive measures to contain virus Spread Island wide by isolating people who had close contact with the COVID-19 positive patients and enforced the police curfew in the area of suspicion as pointed out by the health authorities. The Lieutenant General Shavendra silva said that 85% of the families of that Brandix garment factory were tested positive for COVID-19. The number of COVID-19 positive cases from this cluster has been showing an exponentially increasing trend day by day (Ministry of Defence, 2020). In Sri Lanka, on the 21st of November 2020 subsequently linked clusters were identified in Peliyagoda fish market. The number of COVID-19 positive cases have been increasing exponentially day by day from this cluster too (WHO, 2020).

Under the leadership of His Excellency the President, Sri Lanka pursued a proactive approach to prevent any COVID-19 outbreak within the country. In alignment with this vision, the Government of Sri Lanka (GoSL) implemented early preventative measures even before the pandemic reached South Asia. For instance, on January 26, 2020, the National Action Committee for COVID-19 was established, just one day prior to the confirmation of the country's first COVID-19 case—a Chinese visitor. Following this, on January 28, 2020, the government suspended the issuance of visas on arrival for Chinese nationals. After the first local case emerged, Sri Lanka mandated a 14-day quarantine for all travellers arriving from or transiting through China, Italy, Iran, or South Korea. By March 17, 2020, additional measures included suspending entry visas for citizens from Austria, Bahrain, Canada, Denmark, France, Germany, Iran, Italy, Netherlands, Qatar, South Korea, Spain, and Sweden, alongside a halt on all incoming flights to control the virus's spread (Amaratunga *et al*., 2020).In addition to being proactive, the Government of Sri Lanka (GoSL) implemented strict measures to control the spread of the virus nationwide. These actions included banning all public gatherings, closing educational institutions such as schools and universities, suspending non-essential services, and enforcing an island-wide curfew with work-from-home arrangements for the public (Amaratunga *et al*., 2020).

The Government of Sri Lanka (GoSL) imposed a nationwide curfew on March 20th, 2020, about a week after the first local COVID-19 case was reported. This measure aimed to prevent the virus from spreading further. The curfew was later relaxed in most districts, remaining in effect only during night-time hours, except in high-risk areas. After nearly two months without any reported community infections, the GoSL fully lifted the curfew on June 28th, 2020 (Amaratunga *et al*., 2020).

A key feature of the Government of Sri Lanka's (GoSL) COVID-19 response was its multi-sectoral approach, involving numerous stakeholders. This approach targeted four main Lines of Operation such as military/police/intelligence, medical and healthcare, psychological, economic and community well-being, each requiring collaboration across sectors. The military/police/intelligence, overseen by the Ministry of Defence and involving the State Intelligence Service, Sri Lanka Army, and Police, focused on identifying individuals from affected areas or those exposed to the virus, enforcing self-quarantine or centralized quarantine, locking down exposed clusters, and tracing case origins (Amaratunga *et al*., 2020).

Conversely, the medical and healthcare operations were primarily managed by the

country's public health authorities. This line of operations included tasks such as swift contact tracing of infected individuals, laboratory testing to confirm suspected cases, sampling contacts of confirmed cases, random sampling in high-risk or vulnerable communities, and sampling at border control locations. On April 9th, 2020, Sri Lanka's Ministry of Health and Indigenous Medical Services released the 'Sri Lanka Preparedness and Response Plan COVID-19,' aligned with the WHO's Strategic Preparedness and Response Plan. This plan provided a framework for managing clusters of COVID-19 cases and preparing for potential community transmission. The strategy included four key objectives such as reduce human-to-human transmission, particularly among close contacts and healthcare workers, and prevent international spread, quickly identify, isolate, and care for patients, with special attention to critical cases, communicate essential risks and information to communities to counter misinformation; and lessen the impact through collaboration across sectors and society. The country has been praised for its strong healthcare system and high testing rates during the pandemic. Under the psychological line of operation, the Government of Sri Lanka (GoSL) conveyed essential messages to the public about behavioural guidelines, including handwashing, the use of sanitizers, and maintaining social distancing (Amaratunga *et al*., 2020).

Under economy and well-being of community , the Sri Lankan government introduced a stimulus package for small and medium enterprises, initially setting aside LKR 50 billion (around USD 270 million). This package included working capital loans of up to LKR 25 million (about USD 135,000) for businesses with annual turnovers under LKR 1 billion (roughly USD 5.4 million). However, when approximately 45,000 businesses applied, it became clear that the initial fund was insufficient. Consequently, the government raised the allocation to LKR 150 billion (approximately USD 810 million) (Vithanage, 2020). Additionally, the government partially waived income tax arrears for small and medium scale enterprises, eased payment terms, and temporarily halted legal actions against defaulters. It also introduced a six-month debt moratorium to support impacted sectors, including tourism, garments, plantations, IT, and small and medium scale enterprises. Furthermore, the GoSL provided an LKR 5000 allowance to support low-income families and economically vulnerable groups, such as daily wage workers. The government also implemented maximum retail prices on certain essential goods and created a fuel price stabilization fund (Robinson *et al*., 2020).

5.1. Vaccination for COVID-19 in Sri Lanka

Sri Lanka ministry of health has decided to introduce a safe and efficient vaccine to control the covid-19 pandemic in the country as soon as possible. As they decided, Sri Lanka government approved COVISHIELD vaccine for restricted use in emergency situation in prevention of COVID-19 disease for the persons above 18 years old on 22nd January 2021. COVISHIELD vaccine which is the same Oxford - Astra Zeneca vaccine, which manufactured by Serum Institute of India (SII). Sri Lankan government got 500000 doses of COVISHIELD vaccine on 28th January 2021 which donated by Indian government. Sri Lanka launched its national COVID-19 immunization campaign to administrate the first shot of vaccine in the priority basis, such as all health care workers, non-health support worker who considered as front line workers such as police, STF, defense service and civil defense personnel, Specialized staff at port who directly in contact with possible COVID-19 import cases and Vulnerable aged people

Vaccination campaign had two round, first round conducted from January to first week of February 2021 and the 2nd dose was in one month after the first dose. The vaccine should be stored at 2°C to 8°C to protect from freezing and direct sunlight. Also it is a ready to use liquid non-preservative, multi dose vaccine of 5ml (10dose) and 6 month of self-life from the

production. A dose of 0.5ml of vaccine should be shot by intramuscularly in the left upper arm. Person who got the first shot should complete the second shot in one month after the first shot to overcome the disease (Ministry of Health, 2021).

Side effect of this vaccine have been reported during the clinical trial includes,

Common symptoms are,

1. Tenderness, pain, warmth, redness, itching, swelling or bruising in the vaccinated region.
2. Feeling tired and unwell
3. Chills or feeling feverish, headache, nausea, joint pain or muscle aches

Uncommon symptoms are,

1. Feeling dizzy, decrease appetite, abnormal pain
2. Enlarged lymph nodes, excessive sweating, itchiness and rash.

Sri Lanka ministry of health has also decided to introduce other vaccine such as Pfizer-BioNTech sputnik and sinopharm as a safe and efficient vaccine to control the COVID-19 pandemic. The COVID-19 vaccine as with all other vaccines in use, can have side effects. It may cause minor and temporary side effects, such as injection site pain, mild fever, muscle pain, headache and sometimes chills. More serious side- effects are possible, but very rare. Persons under 18 years old, people who are suffering from acute disease such as high fever, cough, bleeding disorder and shortness in breath, severe allergic reactions and persons with COVID-19 positive or under quarantine and Pregnancy and lactation women are considered as ineligible for the vaccination (Ministry of Health, 2021). COVID-19 vaccines control the outbreak and prevent transmission at the initial stage and gradually boosting and maintaining hert immunity. In addition to the immediate health benefits, COVID-19 vaccination speed-up the economic recovery process that likely yield more return of investments, particularly through building confidence in the tourism sector (Department of External Resources, 2021).

5.2. Future Challenges

With the uncertainty of the COVID 19 vaccines in the foreseeable future, mitigation strategies have been set in place that focus on social distancing, covering of face, frequent handwashing, stay at home regulations, working from homes, and tests taken on by public health priorities. These efforts lead to drastic reduction in the economy of the countries, travelling and business, workforce, food supplies and overload the healthcare system. The COVID-19 pandemic has brought a spirit of collaboration to industries and gives institutions a chance to reimagine what's possible moving forward. The COVID-19 crisis is devastating communities, economies, studies and research around the world. Admonishingly, this COVID 19 pandemic situation is a symptom of a very larger systemic issue, one in which the relationship between human activities and the natural environment is rapidly destabilizing. In the future, Earth, we think that sustainability research can and must support a systems-based approach to managing global public health risks.

6. CONCLUSION

Countries across the world including Sri Lanka, are facing enormous challenges in tackling the disease. Several vaccines have been proven to be efficacious in preventing the Covid-19 infection. Vaccine seems to be the only hope to defeat this pandemic. There is some light at the end of the tunnel. Government of Sri Lanka has implemented several measures to curb the spread of infection. Important features of management of the COVID-19 in Sri Lanka are extensive contact tracing, early intervention, timely isolation of all the possible contacts and providing organized quarantine facilities for contacts.

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