**Cairo University**

**Faculty of Computers and Artificial Intelligence**

# DS241

# Modelling and Simulation

## Research Project

## (The coronavirus era)

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# Introduction

On 11 March 2020 WHO announced that COVID-19 can be characterized as a pandemic, since then so many steps were taken by organizations, countries and individuals. Starting from the prevention in the human scale to travel restrictions and school's shutdown.

There's no doubt the spread of the novel coronavirus pandemic is fast and needs a fast, wise and early decisions to contain the contagion, since it affected many aspects of life and still, we should all show our attention to the current problem facing humanity and as many difficulties faced us from the dawn of mankind to this exact moment, we hope the world can recover soon.

We can think of the current circumstances as lessons for the humanity and before thinking of how to get rid of the pandemic we should think how to prevent a pandemic like coronavirus to happen again and put worst case scenarios so even if it did happen again we can be prepared and contain the disease before it cause a big damage and spreading around the world.

In this research we will cover some of the many things that happen in the coronavirus era, on the governmental scale such as travel restrictions and how some governments successes while other governments failed in containing the virus, and airports tools as traveler's monitoring, contact tracing and procedures that can play a strong role in eliminating the virus from its transmission hubs, then to the technology scale with the Artificial Intelligence solutions, its driven tools and suggestions to help with the problem, to the inside human body's scale and immunity in their attempt to beat the disease and symptoms, and finally we will discuss the clinical trials and tackle the measures of COVID-19 as for SARS and touch on the comparison between them.

# Coronavirus travel restrictions

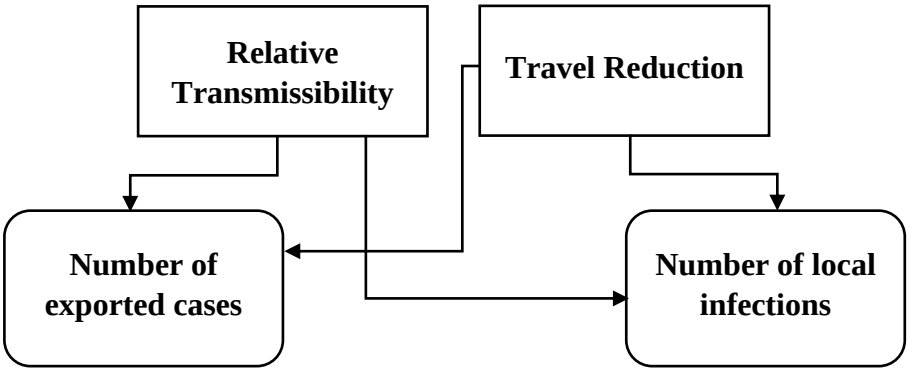
## Purpose

Travel restrictions is one of the governments procedure around the globe to help to contain the coronavirus pandemic, today at least 93% of the world population lives in countries that restrict travels. On 23th January 2020 Wuhan city in China took the step of travel restriction it was the first travel ban during the pandemic and it has a minor effect on China but as for the world this helped delaying the spread of the disease.

## Assumptions

Closing borders and travel restrictions are not the answer to stop the spread of COVID-19 as it only delays the contagion but not solving the root of the problem, it maybe increase the problem as in United States when the travel restriction from Europe to USA has been announced many U.S citizens panicked and rushed back to their home causing crowding in airports which was a suitable environment for the virus to spread among all of these people causing the outbreak in the United stated.

## Structure




Travel reduction isn't the only factor that affects the number of exported cases and number of local infections, relative transmissibility plays an important role combined with travel ban.

## Limitations

The statistical model discussed isn't considering the family travels and assumes the travel probability is identical for each individual and didn't consider the procedures of containment of the disease in airports such as monitoring.

Also delaying the pandemic even it has a small impact inside the country doesn't mean it's not helping globally the other countries and saves them some time to be ready to contain the novel coronavirus.

## Possible Future Work

As transmissibility according to the graphs is helping in decreasing the spread of corona combining with the travel restrictions, the governments can spread the awareness to reduce it by recommending the self-isolation and showing how it's really effective in the pursuit of containing the coronavirus, and learning from the U.S mistake the governments shouldn't narrow the deadline of travel ban and give their citizens the time to comeback with no rush or fear with monitoring the airports with requiring them to do the coronavirus tests and trace the infected people in addition to giving them the quarantine instructions.

## Insights

Wuhan city until 22th January 2020 was without travel restrictions, but on 23th January was the day they announced the lockdown in Wuhan in order to contain the center of the outbreak of corona pandemic.

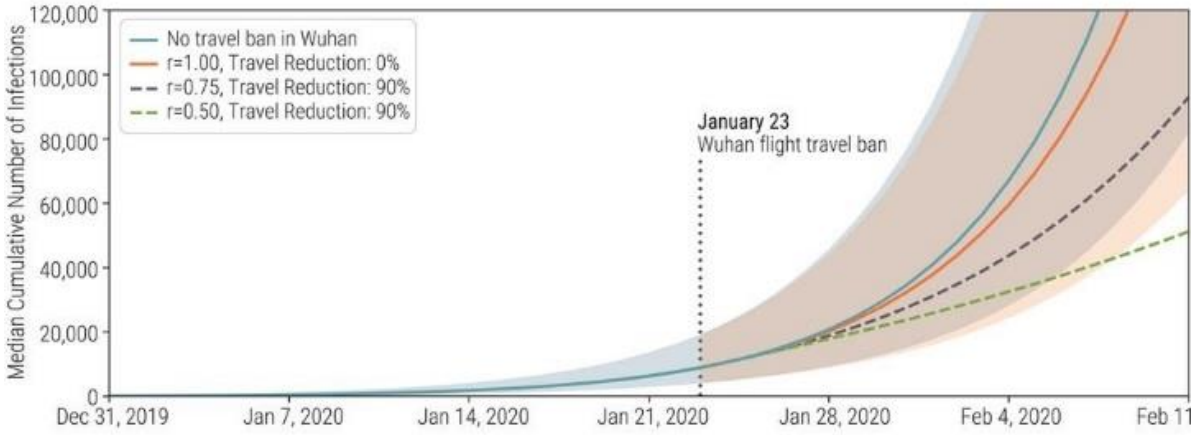



*Figure 1: The effect of Wuhan travel ban on China with different relative transmissibility reduction (r)*

In a s study by implementing an individual-based, stochastic, and spatial epidemic model as showed in the figure above assuming there's no changes in transmissibility (r=1) and disease dynamics it's clear that Wuhan travel ban was not much of a benefit for the virus spread in China but a 3-5 days delay.

Unfortunately Wuhan travel restriction was too late because of the fact that the epidemic was already in different locations in China

On 1st February 2020 China announced a travel restriction. Although it's a big step towards the prevention of the coronavirus from its main source country, if transmissibility isn't reduced (r=1) it only delays the median number of exported cases from China for about 2 weeks or less.

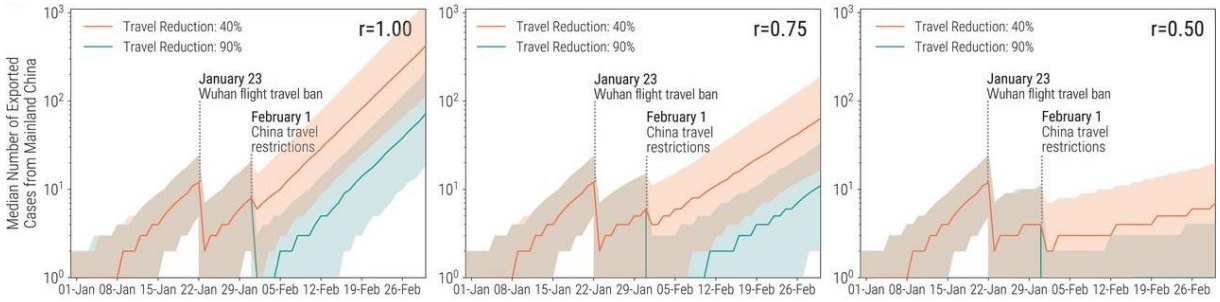



*Figure 2: The exported cases from China after the travel restrictions for different travel reductions and different relative transmissibility reduction (r)*

8 weeks after U.S ban and until mid-March almost 40,000 people arrived from China and many of them didn't receive screening or quarantine instructions which was a big mistake, on the other hand Hong Kong city followed another approach which is leaving borders somewhat open and allowing citizens to return with no rush and gradually requiring them to take the COVID-19 test on arrival and wait for the results, Also Germany and Norway avoided this mistake by a similar approach.

# Monitoring of travelers in the pandemic

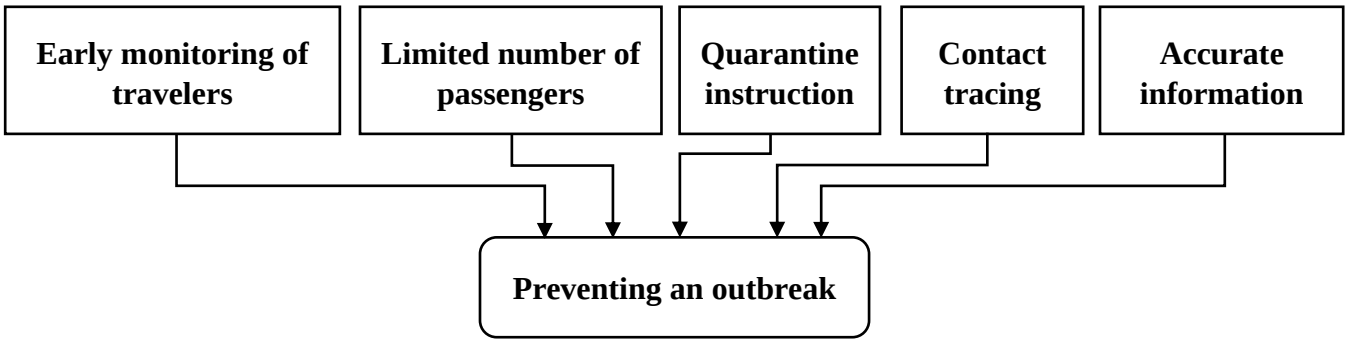
## Purpose

Airports in the coronavirus era became the gateway for spreading the contagion, with no serious procedures such as the lack of staff or passengers registering an accurate information the results can be catastrophic. California's outbreak is an example of failing to contain the pandemic and how it can cause a serious damage if not implemented earlier or in a wrong way.

## Assumptions

By applying an early and well-handled monitoring of travelers it can prevent an outbreak and identifying the infected travelers' information can make an easy contact with them for follow-ups and giving them a good instructions for 2 weeks quarantine and trace the people who came into contact with them

## Structure




Some factors that affect the prevention of an outbreak are: early monitoring of travelers in the initial phase of the pandemic, limiting the number of passenger to prevent flood of travelers, good quarantine instructions, contact tracing and accurate information of passengers

## Limitations

The infection during the flight in the airplanes plays a big role in the transmission of the contagion among the travelers, also the new infected travelers of the coronavirus in the airplanes will show no symptoms or can't be identified with temperature cameras when they arrive at the airport which doesn't deny the fact that they can infect other people in their way out of the airport, expanding the range of testing to not only test for those who carry the disease but also the people who doesn't show any symptoms will also help in better containment of an outbreak.

## Possible Future Work

Making disinfection tunnels and thermal scanners on the airports' entrance will help in identifying the infected passengers, Also airports can be information hubs in spreading the awareness of COVID-19.

IoT and application development fields can be so much of a help if airports invested in making devices that makes it easy to screen travelers and monitoring them and their temperature and alert the staff if there's any suspected behavior besides an easy contact through the application.

## Insights

Airports screening, quarantine and monitoring of travelers has been an effective way in stopping Ebola, but when speaking of Coronavirus pandemic the situation is more challenging to implement as in California outbreak.

On 5th February 2020, several weeks after the virus is first identified in Wuhan, A program for identifying travelers coming from high-risk countries and monitoring them has begun in California.

California state health employees spent about 1,700 hours over six week collecting and processing the information of U.S citizens from China and Iran at California airports and they were able to identify only three positive cases for coronavirus out of 11,574.

With the flood of travelers, the California program became inefficient against this amount of passengers besides the inaccurate information of travelers, which 1500 records (about 13%) had at least one wrong info, caused the California outbreak. Another reason was that a disease like coronavirus the transmission can occur before the symptoms arise.

As a result on 17th March 2020 the California program was abounded to focus on controlling the spread of the novel COVID-19 and prevent the explosive growth of the outbreak within California itself. Compared to Ebola travelers monitoring, California encountered a median of 1,431 passengers per week coming from Asia, on the other hand only 21 people per week came from affected African countries during the Ebola outbreak in 2014-2015 which was successfully contained then.

A study from C.D.C recommends doing travelers monitoring although it's more effective during the initial containment phase of the outbreak, it also endorses the California program once the outbreak is under control to prevent another wave of incoming passengers, but wish an accurate information and using text-messaging to communicate with passengers after the leave the airport.

# Artificial Intelligence application for COVID-19

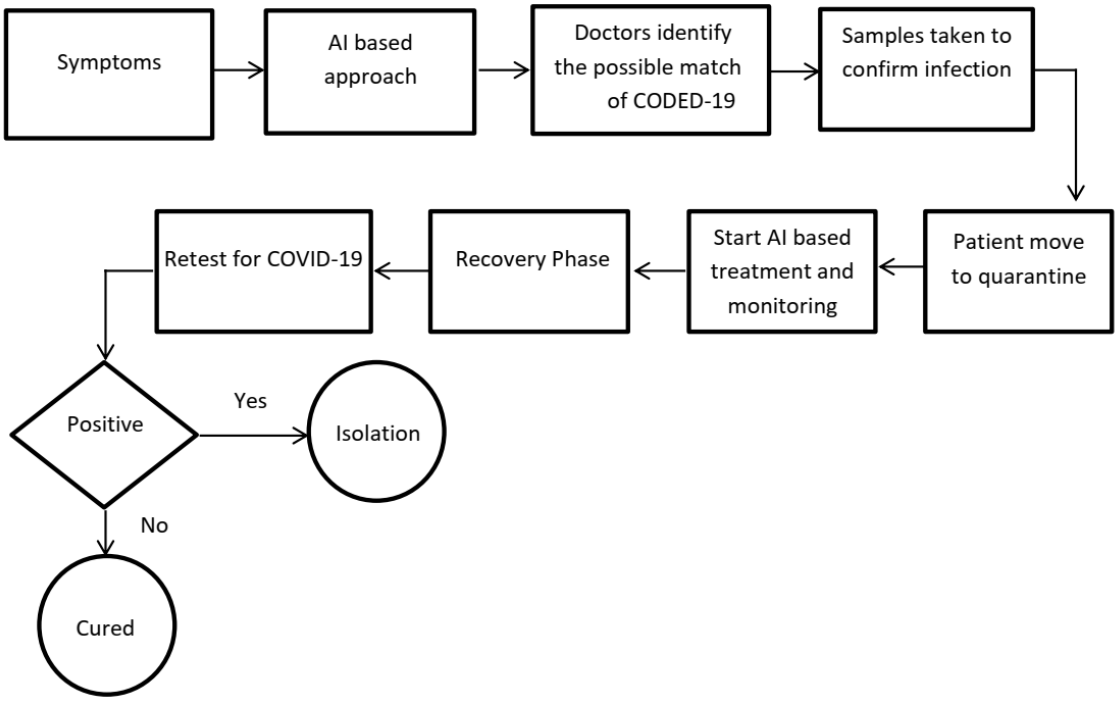
## Purpose

Healthcare requires the support of new technologies like Artificial Intelligence (AI), Big Data and Machine Learning to fight against the new diseases. The aim is review the role of AI as a decisive technology to analyze, prepare us for prevention and fight with COVID-19 and other pandemics.

## Assumptions

The model identifies application of AI for COVID-19 pandemic. This technology is an important role to detect the cluster of cases and predict where this virus will effect in future by collecting and analyzing all previous data.

## Structure




## Limitations

Considering all people is patients and then applying all steps to be surely they converted to negative case, then they can move from quarantine to their home is a wrong approach, because there's people who have a good health.

## Possible Future Work

The model can be modified to handle all the exception cases found out there due to the coronavirus pandemic around the globe and developing a more, fast and effective recognition and treatment plan.

## Insight

AI can analyze irregular symptom and thus alarm the patient and healthcare authorities. It helps to provide faster decision making, which is cost-effective.

It helps to develop a new diagnosis and management system for the COVID-19 cases, through algorithms. AI is helpful in the diagnosis of the infected cases with the help of medical imaging technologies like Computed tomography (CT), Magnetic resonance imaging (MRI) scan of human body parts.

# AI-driven tools in Coronavirus outbreak

## Purpose

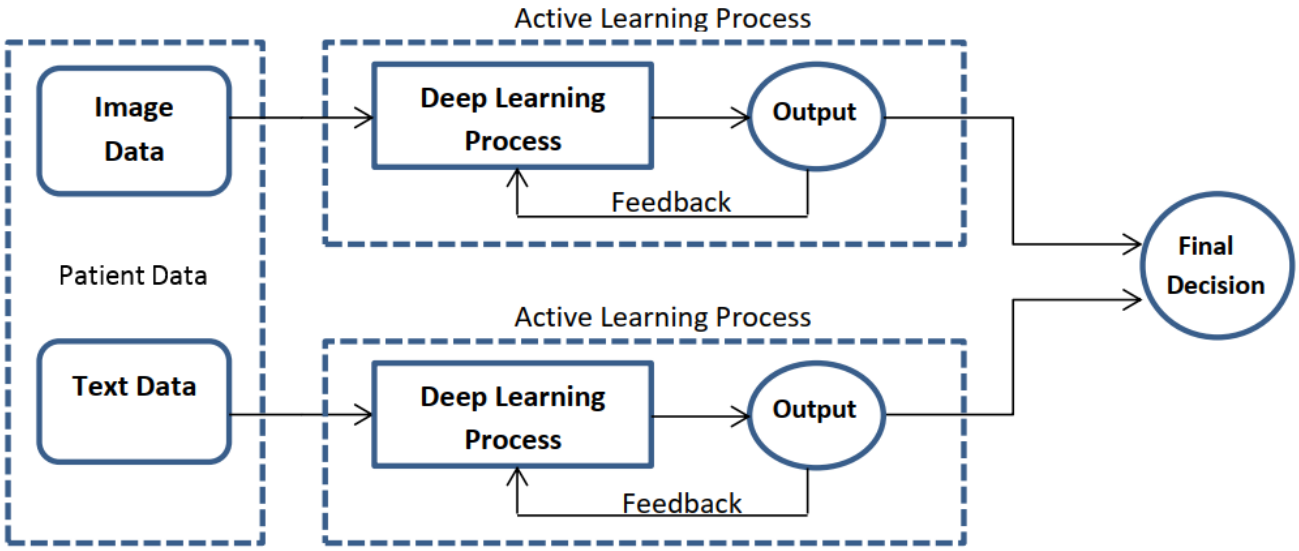
One of the main purposes of this model is to introduce the importance of Artificial Intelligence (AI) driven tools and techniques and its capabilities such as train and test models. The second purpose of this model is that scientists don't need to wait for complete data sets, they can use AI-driven methods in the beginning of the data collection side by side with experts in the field, as an implementation of active learning. Other purpose is to employ several data types to get higher confidence during the decision making process, rather than depending on one data type.

## Assumptions

Novel coronavirus outbreak can be identified easily by using AI-driven tools as well as forecast their nature of spread across all over the world.

To use AI-driven tools efficiently we need to collect a sufficient training data for all cases. Classical Machine learning need a clean set of annotated data so that classifiers can be well trained which falls under the scope of supervised learning.

## Structure




## Limitations

Most of AI-driven tools are very limited to proof-of-concept models for corona virus case. In addition collecting large amount of non-trivial data set needs a more long time.

## Possible Future Work

This model is developed to work more efficient with specific data this means that no need for a more data and time to output the final decision. The model will be better in the near future by proving a bigger database of image and text data and using a high-performance devices to output the results faster and more accurate, we also can make them open source to have the power of collaboration globally.

## Insight

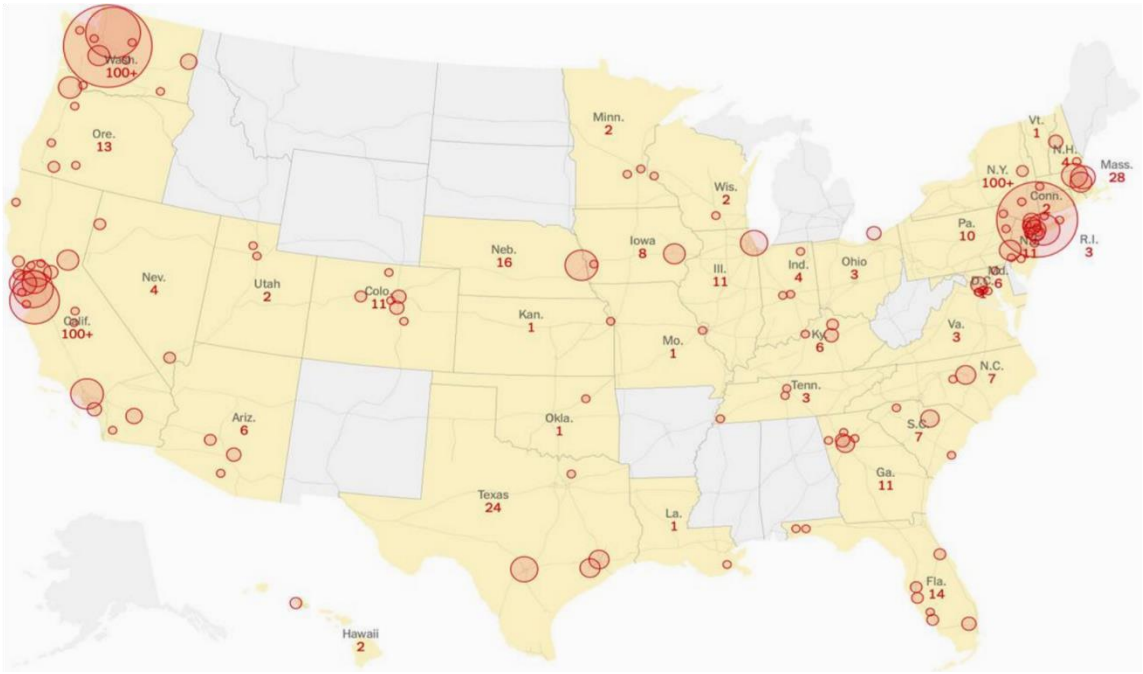



*Figure 3: Known locations of coronavirus cases in the United States*

Coronavirus was not a surprise case, since several years ago, in 2003, a novel coronavirus was identified in patients with SARS, and it thought to be caused by an unknown infectious agent.

# Coronavirus effect on infected people

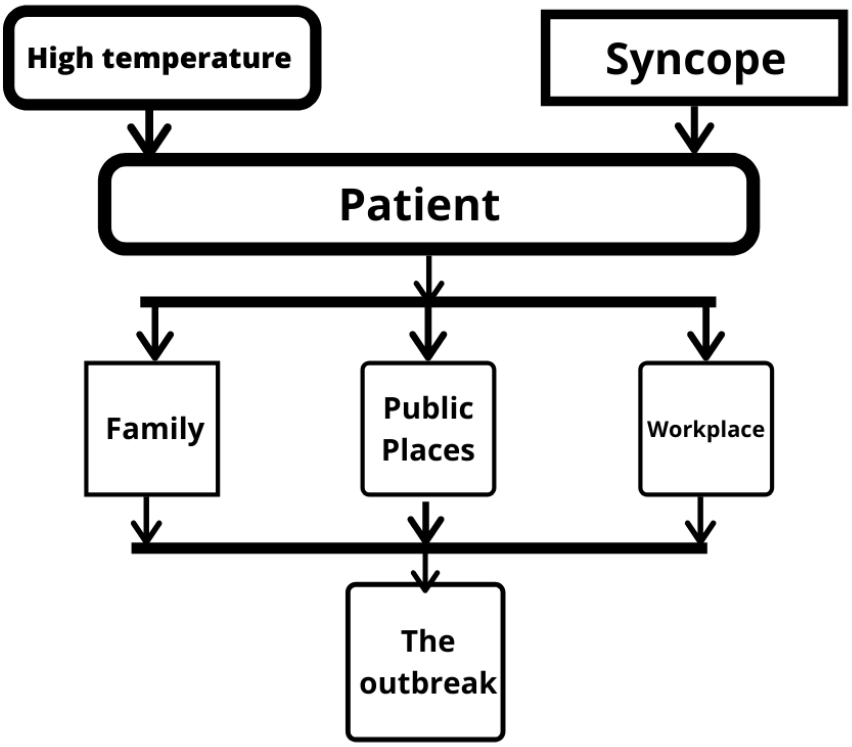
## Purpose

The aim of dealing with the symptoms of the infection is to reach an appropriate treatment, or at the very least, take the necessary precautions to prevent the outbreak of the new Corona epidemic.

## Assumptions

We can say that the symptoms of the Corona virus are not very different from the symptoms of the common cold and influenza. This is due to the fact that the new Corona virus is a type of virus that infects some types of animals and we do not know the main source of the cause of the outbreak until now.

## Structure




The first stage is the symptoms of infection, in most cases it is a cough, pain in the throat and a high temperature with fatigue and fainting.

In this case, the suspect who has these symptoms is a carrier of the disease, and here is the second stage where the patient does not know that he is infected and begins to practice his daily life mixing with others, others are injured and the third stage begins which is the spread of the epidemic.

## Limitations

There are some values that determine the transmission of infection from one patient to another, including approaching a distance of less than one meter between the patient, contact between the patient and others and the use of the same household appliances used by others, touching the surfaces that have been exposed to the virus.

## Possible Future Work

In the near future we can start to use medical tools such as gums and sterilizers, and hospitals begin preparing the equipment for treating the infected with the virus.

## Insights

Firstly, adhere to the home stone and get as far away from public crowds as possible.
Second, the continuous sterilization of surfaces and tools that we use daily.
Finally, help spread awareness among citizens so that we can control the disease.

# Coronavirus prevention and treatment methods

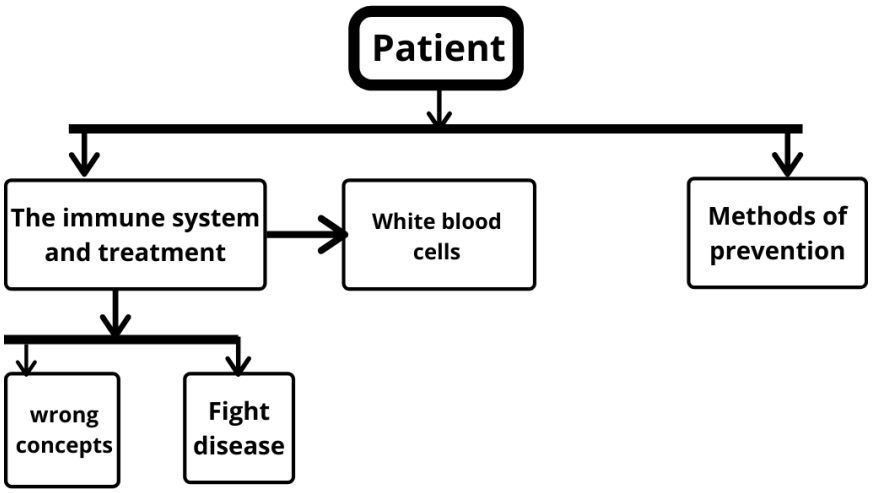
## Purpose

Since the appearance of the Corona virus until now, we have not found the appropriate treatment yet, and although most of us have stopped prevention methods, we still need them to eliminate this pandemic.

## Assumptions

Some believe that strengthening the immune system in the body will work to eradicate the disease, well this is true that the immune system is the main defender until now, but working to strengthen the immune system does not help.
On the other hand, we can analyze the resulting cells in healing cases so that we can get treatment for this disease.

## Structure




When the body becomes infected with a strange disease, the immune system begins to pump large amounts of white blood cells, which do the work of the inspector. When the immune system detects a foreign cell, it immediately destroys it, or at least it fights it little by little until it completely destroys it.

This method is represented by some symptoms that accompany the patient's body, such as a rise in temperature and heat, and some fatigue and digestive problems. This is the stage where the patient resists the virus until the immune system destroys it.

## Limitations

Some of the problems related to the Corona virus and the immune system are that some patients are weak immune, and their bodies cannot fight the disease so they need medical intervention.

There are some misconceptions such as ways to raise and strengthen the immune system, and this cannot happen no matter how much a person takes drugs and medicinal herbs, but there are some vegetables and herbs that work to preserve and not strengthen the immune system.

## Possible Future Work

Until now, there is no treatment for the Corona virus, but some medical devices and agencies are working on analyzing the confrontation between the Corona virus and the body's immune system, so that they can produce the appropriate treatment for all infected cases.

It may take a lot of time for this to happen, and for this must maintain the necessary prevention and sanitary isolation until scientists finish developing the appropriate drug for treatment.

## Insights

Now we only have to maintain our mental and physical health and stay safe and follow the health organizations’ instructions and follow a good personal hygiene and self-isolation until we find a treatment to this novel coronavirus pandemic.

# Preserving clinical trials on covid-19

## Purpose

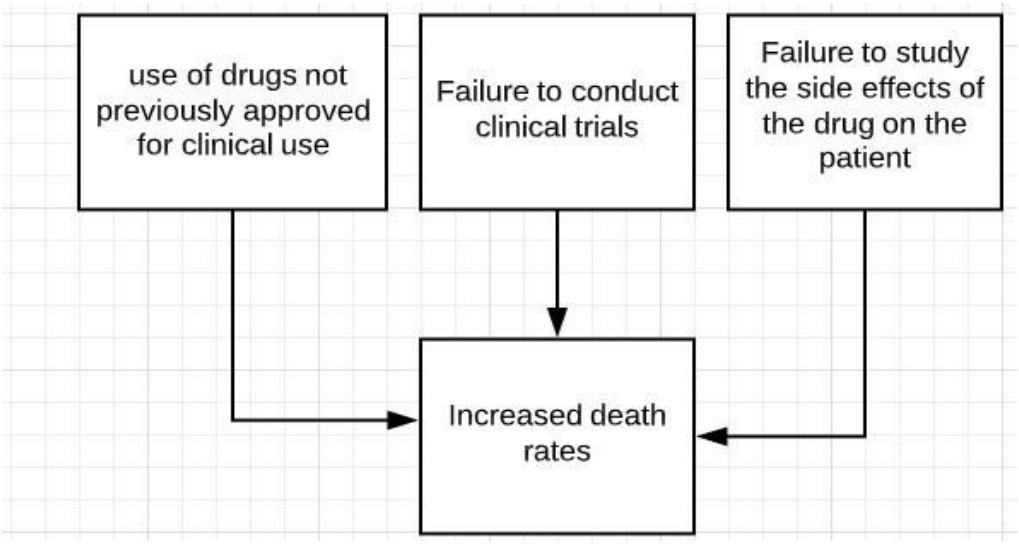
In the 2014 about 30 000 person were infected with a virus Ebola, Several treatments have been developed and implemented like hydroxychloroquine, favipiravir, brincidofovir, antisense RNA and convalescent plasma, the goal was to determine which was effective against Ebola virus but, ultimately, none proved to be efficacious or safe.

Among the reasons why we did not need it, because they were simultaneously without synchronization and in the end all these experiments failed. So our goal is to talk about Preserving Clinical Trial on covid-19, which without this Preserving can lead to severe consequences.

## Assumptions

Lack of credibility in detecting and announcing the actual numbers of patients and clinical and random experiences in conducting bed tests are dangerous matters that lead to the spread of the disease and not containing it, and it is possible that the ongoing experiments can benefit millions of people with chronic debilitating diseases long after the end of the Corona virus pandemic. Moreover, stopping current experiments wastes previously invested resources and wastes the time and effort of participants who may have already completed the experiment.

## Structure




## Limitations

Although the risks of bedside experiment in fighting the virus and the ineffectiveness of the drug, it has some negative effects on patients or labs, but clinical trials should not stop because without them there

will be no treatment to eliminate any epidemic, so clinical trials must be held, but they must be very accurate to be with the participation of many scholars and The results that can be collected remotely.

## Possible Future Work

Some of the solutions that I see will put an end to the emergence of the virus. Continuing in clinical trials and safety in conducting clinical trials and not making people as mice experiments and spreading the policy of spacing between people and the continuation of the total household isolation for the longest period to reduce the emergence of the virus and also that there be a period until the recovery of the last case in The place where the virus is spread and, lastly, the medical staff at the highest level and take care of their psychological condition.

## Insights

The world is now controlled by covid-19, no final treatment has been discovered yet and it is treated with permanent care in hospitals and home isolation.

Many experiments were conducted and medications that are inherently known to be resistant to viruses such as hydroxychloroquine and anti – IL-6 inhibitors. Although many drugs have laboratory activity against different corona viruses, there is no clinical evidence currently supporting the efficacy and safety of any drug against any corona virus in humans.

However there are published case reports of old and new drugs having laboratory activity against SARS-CoV-2 given to patients but without a comparison control group. Managing any medication that is not proven to be a last resort wrongly assumes that the benefit will be more than harm.

Nevertheless, when a novel disease administers a medication of uncertain health results to people with serious illness, there is no means of telling that people have gained or been affected. A common explanation for off-label use and sympathetic use of medications is that if a patient dies, he dies of illness, but if the patient survives, he survives because of the given medication, this is not true.

As a practical example hydroxychloroquine, azithromycin, and lupinavir-ritonavir have a variety of negative effects, including QT prolongation, point fasciitis, hepatitis, acute pancreatitis, lack of neutrophils, and anaphylaxis. Given that most of the patients who died due to COVID-19 were older and had cardiovascular disease and that patients often suffer from arrhythmias and 4, 5 chloroquine / hydroxychloroquine and azithromycin and lopinavir-ritonavir can increase the risk of death Heartfelt. Additionally, hepatitis and neutropenia are clinical manifestations of COVID-19, and both impaired liver and bone marrow functions can be exacerbated by the use of these off-label drugs. Thus, it would be impossible to distinguish between the drug-related harmful effects of the manifestations of the disease in the absence of the control group.

Compassionate use of drugs not previously approved for clinical use (for example, remdesivir) can cause dangerous adverse effects not previously detected due to the very small number of patients exposed. With regard to anti-inflammatory therapy, intravenous steroid use was associated with delayed

removal of corona viruses in the blood and lungs with MERS-CoV6 and SARS-CoV, 7 and steroids were associated with a significant increase in risk of death and secondary infection in patients with influenza. Moreover, even low-dose steroids have shown harm in patients with sepsis, and IL-6 inhibitors may cause deeper immune suppression than steroids, which increases the risk of sepsis, bacterial pneumonia, gastrointestinal perforation and hepatotoxicity. 9, 10 However, Despite significant evidence of potential harm, steroids and IL-6 inhibitors are now given to patients with COVID-19 in many countries, Now in Italy, France and Spain, a large number of patients have received unfamiliar and compassionate use treatments.

# COVID-19 outbreak and measures as for SARS

## Purpose

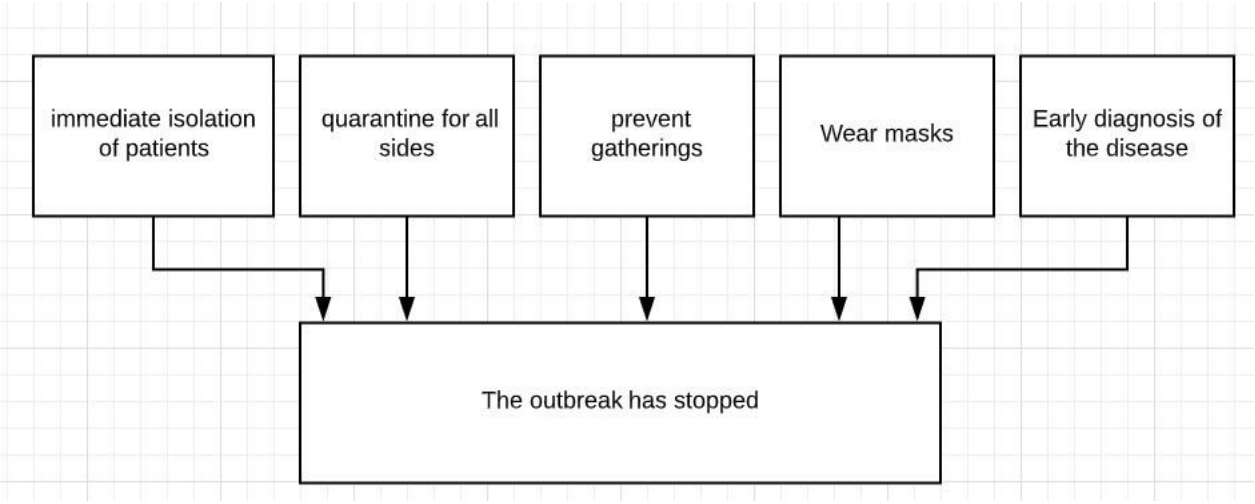
We will make a simple comparison between covid-19 virus and the SARS virus, and we can see whether we can with the current measures that most of the world is going to eradicate the current spreading covid-19 virus and how strong it is and is it more dangerous than the SARS virus that has spread in many countries and we will see how these countries were able to eliminate virus.

Also, we will talk about deaths caused by SARS virus and covid-19 virus, and whether the cure rate in the covid-19 virus is high compared to the number of infections or not.

## Assumptions

In our hypothesis, we will use some of the measures that were taken at the time of the spread of the SARS virus in 2003 until covid-19 virus was eradicated due to the similarity between them and so far the measures that were taken at the time of the SARS virus are the most effective because there is no actual drug so far and we will make a simple comparison between SARS and a covid-19.

## Structure




## Limitations

The spread of research indicates that the Corona virus can eliminate it by increasing the temperature, which was recently denied and covid-19 is more dangerous than SARS.

## Possible Future Work

Spreading the policy of spacing between individuals, dividing the number of working hours and employees so that there is no accumulation in public transport, constantly conducting medical examinations, isolating suspicious cases according to the rules of the World Health Organization, and signing large fines for violators.

## Insights

In 2003, the SARS virus spread to more than 8,000 deaths and 800 deaths, but SARS was eventually contained and the methods were as follows. Surveillance, immediate isolation of patients, strict enforcement of quarantine for all communications, and in some areas top-down enforcement of community quarantine. By stopping every human-to-human transmission, SARS has been effectively eliminated.

Although there is a great similarity between SARS and COVID-19, differences in the characteristics of the virus will ultimately determine whether the same procedures for SARS will work for COVID-19 or not. So far, COVID-19 infection rates have been estimated at more than 5,029,841. Mortality is estimated at more than 326,155, and the cure rate is more than 1,982,741. By reviewing the statistics, the prevalence of COVID-19 virus is greater than the prevalence of SARS virus, as SARS virus has spread in 26 countries, while COVID-19 has spread in most countries of the world. The similarities between SARS- CoV and SARS-CoV-2 are amazing, not just by name. The complete genome of SARS- CoV-2 is similar to 86% with SARS-CoV. 1. Both viruses share high levels of symmetry with isolated SARS-like covid-19 in bats, indicating that bats are the potential origin of SARS-CoV and SARS -Cove-2. It is believed that live animal markets selling various types of wild animals are close to large numbers of people.

There is a clear similarity between them as the main transport route is believed to be respiratory drops, although viral shedding through feces has been reported for both viruses. The angiotensin-converting enzyme 2 (ACE2), found in the lower respiratory tract of humans, has been identified as a receptor used to enter cells for both SARS-CoV and SARS-CoV - 2.2, 3 COVID-19 and SARS with an average incubation period of about 5 days. The average serial interval for COVID-19 is 7 · 5 days (95% CI 5 · 3-19 · 0) and the primary estimate for baseline (R0) was 2 · 2 (95% CI 1 · 4–3 · 9), 4 is similar to that reported for SARS (mean, serial time interval 8 · 4 days, and baseline R0 range 2 · 2–3 · 6 for serial periods ranging from 8 to 12 days).

Despite the similarities, the prevalence and number of infections is different, SARS has spread very significantly in some of them. China, Taiwan, Hong Kong, Singapore, Toronto, Canada, but within 8 months the disease was contained and eliminated.

The methods used to eliminate the disease are Syndrome follow-up, immediate isolation of patients, and quarantine for all sides and prevent gatherings and therefore stop the virus from transmitting from person to person.

# Taxonomy

The models discussed can be organized and categorized as follows:

1- Travel and airports during the pandemic:
   - Coronavirus travel restrictions
   - Monitoring of travelers in the pandemic

2- The role of Artificial Intelligence in fighting COVID-19:
   - Artificial Intelligence application for COVID-19
   - AI-driven tools in Coronavirus outbreak

3- People's immunity and symptoms:
   - Coronavirus effect on infected people
   - Coronavirus prevention and treatment methods

4- Current thoughts and trials to treat the novel coronavirus:
   - Preserving clinical trials on covid-19
   - COVID-19 outbreak and measures as for SARS

# Conclusion

We can say the war against the coronavirus needs the support of both people's awareness and the good government's decision, the technology can play a great role as we discussed the AI applications. Giving the attention to the researches by funding and the people by spreading awareness ads and psychological support can make a difference. Yet we have seen that self-isolation and following the hygiene rules are simple tools to prevent the contagion, until we discover a cure we can start from here. Also the governments should think about the consequences of the decision before announcing it because a bad decision on this scale not only effects this country but also the whole world. Airports as we have shown are transmission hubs of the disease and the airports companies can support the researches and show their concern about the case and also develop technologies for a better monitoring and contact tracing.

The spread of the novel coronavirus pandemic can be illustrated as a long chain that each infected person represents a link in this chain. So everyone can start with themselves and be a part in the prevention of the spread of coronavirus.

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