COVID 19 Management Strategies:

A Study

Summer Training – Part 1

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A Report

by

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COVID 19 Management Strategies - A Study

Abstract

Objectives: The Coronavirus Pandemic has taken the world by surprise. Health systems across the globe were not ready to tackle a public health crisis of this stature. This qualitative research aims to study the epidemiological characteristics of COVID-19, compare the existing health systems of 5 countries across the world – China, U.S.A., South Korea, Italy, and India, along with studying their response to their specific COVID-19 outbreaks.

Methods: Taking the help of digital prints of health journals, newspaper articles, recently published research articles and 1st year modules from the IIHMR University, Jaipur, the objectives were studied step by step and an attempt was made to draw suitable from the preliminary data and information available.

Results: Up to May 31, 2020, China had managed its outbreak effectively by applying stringent rules and regulations. U.S.A., still dealing with the crisis, struggled to get a hold on the situation since the get go. South Korea, with the use of advanced technology and proactive administration, successfully managed the crisis. Although a second wave of the outbreak was feared to have started in South Korea, there has been no definitive evidence of the same. Italy, saw a very high COVID-19 mortality largely due to their aged population. India imposed lockdowns during the initial few weeks, which is expected to show delayed rise in cases.

Conclusion: South Korea model of management of the ongoing crisis has been studied across the world. It set the benchmark by recording very few deaths, compared to other countries, most of which is owed to their effective management using all possible resources.

Introduction

COVID-19 is a viral infection caused by the Severe Acute Respiratory Syndrome coronavirus 2 (SARS-CoV-2) virus, which comes from the family of coronaviruses (CoV).

This family of viruses is said to transmit initially from animals to humans. In the case of SARS-CoV-2, bats have been identified as the source of infection.

The infection started particularly from the Huanan Seafood Wholesale Market in the city of Wuhan in China, in late December 2019, after which it spread to the Hubei Province and later to other parts of China and the World.

The virus spreads through droplet infection, either through saliva, or discharge from the nose when an infected person coughs or sneezes.

The incubation period for the novel coronavirus is said to be anywhere between 1-14 days. In most cases, an infected person shows mild to moderate symptoms including dry cough, breathlessness, and fever. The susceptibility tends to increase in persons who have underlying medical conditions, especially breathing problems and immune-suppressive conditions.

Scope of the Study

The study will be helpful in terms of the following:

1. **Trend analysis**: By studying the similarities and differences of this virus with the previous outbreaks and epidemics, we can carry out a trend analysis. This will give us an idea about the direction in which communicable diseases with pandemic potential are going, and how much do government across the world need to worry about the likelihood of another such disaster.

2. **Future readiness:** The coronavirus was a novel virus which has never been dealt with before, anywhere in the world. The situation we are in today begs the question that given the rising temperatures and deteriorating environment, is it not possible that more such novel viruses make their way into existence and pose a threat to humanity? And if this happens, will we be ready to tackle another such attack? This is where future readiness comes in. World over, studies can come to logical conclusions as to what works and what doesn't. Standard Operating procedures can be defined as a result of these studies.

3. **Vaccine development:** A disease is never fully dealt with until and unless there is a vaccine for it. To develop a vaccine, there need to be rigorous studies and trials of thousands of test subjects before it is made available for public use. Even after its development it takes years or even decades to get to 100% distribution among the population.

4. **Inequities**: During natural disasters or global crises, the societal inequities tend to surface. Therefore, the current situation is the perfect time to study this aspect, especially in relation to Behavioural sciences.

5. **Impact:** To create a legitimate database for future use and to assess the impact and extent of destruction caused by the virus, extensive studies need to happen. The timing of these studies can be different, for example, some studies may need to be conducted once the crisis is over so that there is availability of data, whereas other may need to be done more urgently to contribute to averting further damage.

6. **Controllability**: Whether or not the spread of a disease was preventable and at what time and place should the intervention have been added to prevent it from spreading to the whole world, are all research-based solutions. It is imperative that we study controllability of the disease to know where our stops need to be placed if this or a similar situation arises again.

7. **Policy implications**: Many studies influence policy-level decisions, especially when related to science. The healthcare spending of various countries may need revision after such a big blow to their inadequate healthcare systems.

Objectives

This study objectives are-

1. To study the health systems of various countries across the world
2. To study epidemiological aspects of the pandemic
3. To study management strategies adopted by various countries to combat the COVID-19 pandemic

Methodology

The sources used in the formulation of this report are:

- Newspaper articles (digital)
- Articles from various journals worldwide
- Recently published research studies
- Modules provided by the IIHMR University during MBA HM first year

Step 1: Gathered facts and data about the Coronavirus, its characteristics, its previous forms, and how it spreads.

Step 2: Broadly studied various countries and how they were dealing with the COVID-19 pandemic.

Step 3: Selected 5 countries on the basis of various factors which are explained later.

Step 4: Started collecting data on demography, healthcare systems, and health status of the population of these five countries, namely, China, U.S.A., South Korea, Italy, and India.

USA and Italy were included to study the reasons for the sheer enormity of the crisis in these economically sound countries. A part of the discussion focusses on how their management model differed from the successful models across the world, and even faltered in doing what it set out to do. Even within these countries, there were regions that performed well relative to the rest of the geography.

South Korea was chosen because it has shown immense wisdom and proactivity in the use of resources for generating a viable strategic plan to combat the crisis and flatten the curve. This presented as an opportunity to look into whether or not the S. Korea model could have been replicated in other countries that didn't do so well in terms of management, and if not, why.

In spite of being the second most populous country after China, and a developing economy, India exercised a complete lockdown (the largest in the world in terms of number of people in lockdown) out of all countries dealing with the pandemic. There have been competing views on the legitimacy, need, and the long-term price to be paid (both economically and financially) for this lockdown, which will be further discussed in this study. The death rate in India appears to be lower than other places, even when the living standards of the society, on an average, are lower than other comparable economies (economic comparison as of 2019). In this study, we look into the reasons why the Indian population, although largely unorganised and highly dependent on human interactions, has been relatively much less affected (in terms of death rate) by COVID-19.

Step 5: Carried out an in-depth analysis of the management of the COVID-19 outbreak in the 5 selected countries (up to May 31, 2020) and compiled them with the data collected formerly to create the first draft of the report.

Epidemiology of COVID-19

The World Health Organisation (WHO) defines Epidemiology as "the study of the **distribution** and **determinants** of **health-related states or events** (including disease), in **specified populations**, and the **application** of this study to the control of diseases and other health problems."

Epidemiological Indicators

- **Case Fatality Proportion**[23]:

$$\text{CFP} = \frac{number\ of\ deaths\ due\ to\ a\ specific\ disease}{total\ number\ of\ cases\ due\ to\ the\ disease}$$

It gives an estimate of the severity of the disease. Since the pandemic is still ongoing, reliable data on the number of cases and deaths is not available yet. This, combined with the fact that all those with the infection have not been tested, tells us that this measure can only be accurate in retrospect, and right now, can give a vague idea at best. As on March 3, WHO **estimated** a mortality of 3.4% (3.4% of the reported cases have died), which was earlier (in the end of January) said to be 2%.

- **Mortality Proportion[23]:**

$$\text{MP} = \frac{total\ number\ of\ deaths\ due\ to\ specific\ disease}{total\ poulation}$$

While CFP relies on a changing denominator, in MP, the denominator remains same. This acts as an advantage when comparisons are made once the epidemic is over. However, the disadvantage is that during early phases of the epidemic, MP may be biased due to the rapidly increasing deaths (numerator), but stable population (denominator). This means that for different phases of the epidemic, MP would differ.

- **R_0 (Basic Reproduction Number)[23]:** This denotes, on an average, the number of persons that one infected person transmits the infection to, in a population which does not have immunity to that disease and there are no specific control measures against it. From this, we get to know the rate of spread of the disease. R_0 can thus only be assessed when an infection occurs for the first time in a population. It is a theoretical measure which remains constant for a specific infection in a specific population. Initial estimates of the R_0 value for COVID-19 were between 1.4 to 2.5.

- **R_t (Effective Reproductive Number)[23]:** This denotes the number of persons to whom the infected person transmits the infection, when infection control measures are in place and a portion of the population is immune.

$$R_t = R_0 \times \textit{proportion of susceptible persons in the population}$$

This means that R_t is dynamic throughout the course of the epidemic. Practically, this figure is used as a parameter to judge the need for a lockdown. If this number is greater than 1, i.e. one person is infecting more than one people, a lockdown may be the way to go to bring this number below 1. Once it is less than 1, the risk of spread of the infection decreases manifold. However, this does not mean that the outbreak cannot take place again. Even with a single remaining case, and with no evidence of Herd Immunity, there is always the risk of a second wave.

- **Incubation Period[23]:** The time between infection and development of symptoms. For COVID-19 the incubation period is anywhere between 1-14 days.

- **Herd Immunity:** This phenomenon occurs when a certain proportion of the community develops immunity to the infection (after getting infected), and, as a result, stops its further spread. A threshold proportion is defined for most infectious diseases, which gives us an idea of the minimum percentage of population that needs to get infected before herd immunity kicks in.

Allowing herd immunity to develop through natural infection is a dangerous path, as argued by many experts. This is because it results in a large number of preventable deaths.
The development of herd immunity via vaccines is the safest method.
In case of COVID-19, the threshold lies somewhere between 29-80%.[34]
Although development of a vaccine is underway throughout the world, the time till it becomes available for public use is still far.

COVID-19 v/s Past Outbreaks or Pandemics

In the 20th and the 21st century, almost all pandemics have been caused by an Influenza virus or a Coronavirus. The impact of each one was different, partly due the characteristics of the virus itself and partly due to the difference in the environment which they affected.

To study the present COVID-19 pandemic in detail, it's important to address the similarities and differences it has with past pandemics.

The Spanish Flu, 1918 –

The Spanish flu was very widespread. This can be owed, firstly, to the fact that there was an ongoing war (World War 2) due to which the men in the armies were constantly travelling, and taking the infection with them. Secondly, hunger, starvation, and unsanitary living conditions made the environment perfect for an infection to breed.

Like the SARS-CoV-2, Spanish flu also transmitted through droplet infection. About 1 in every 3 people across the world were infected[29]. Its most striking difference with SARS-CoV-2 is that it while the latter tends to affect the older age groups more severely, the former was much more dangerous in the young population. So much so that half of all the deaths due to Spanish flu were between the ages of 20 and 40.[28]

H1N1 Swine Flu, 2009 –

The H1N1 virus caused a relatively mild infection, with almost no need for hospitalisation. Like the Spanish flu, 87% of the mortality by swine flu was under the age of 65 years, unlike the SARS-CoV-2. The Basic Reproductive Number (R_0) for swine flu was around 1.4 to 1.6, which made it less transmissible than SARS-CoV-2.

In both the abovementioned cases, older adults seemed be immune to the infection, suggesting similar viruses which infected and immunised them decades ago[28].

SARS 2003 –

SARS had a much smaller impact than the present outbreak. The similarities between SARS and the novel Coronavirus include both being a respiratory infection spread through droplets. However, the major difference is that for SARS isolation was an effective strategy, because the virus was transmitted only after the patient had started showing symptoms, i.e. there were no asymptomatic infectious carriers.

Also, SARS-CoV-2 has a higher transmissibility than SARS. Given that the Case Fatality Rate of SARS was much higher (10%) compared to that of SARS-CoV-2 (estimated to be

around 2%), the higher transmission of the latter would result in many more cases than the former and, ultimately, a much higher mortality[30].

Since the last pandemic, a lot has changed around the world. China, in particular, has become a manufacturing hub. The outbound travel from China has doubled and the urban population density has tripled in the past decade. In central China, Wuhan is centre for commerce, industry and transport. The busiest train station and airport of central China are located here, along with the largest deep-water port[30].

Results

The Framework being used to discuss the COVID-19 situation in 5 countries is based on the basic healthcare structure, demographics and behaviour of the population towards health.

In particular, following are the headings under which facts, statistics and data have been discussed:

1. Demography
2. Health Status of the population
3. Structure of the Healthcare system (Including Public and Private Healthcare provisions as well as Health Insurance Schemes)
4. The COVID-19 timeline in the country (until May 31, 2020)
5. COVID-19 Management Strategies

Country 1: China

The COVID-19 pandemic originated in Wuhan, China. Since it was a novel disease, China trod upon the virgin territory of devising management strategies for the same. In other words, China was the first to be exposed to this crisis and the first to tell the world how to deal with it. In the course of these few months (December 2019 to May 2020), China made several corrections in the case definition, and as an extension, official figures, which led to bad blood between China and some of the other leading economies of the world, including the USA. Being a pioneer in dealing with the novel Coronavirus and all the economic, social and health problems that tag along with it, not to mention that it is currently the most populous country on the planet.

Table 1.1: Demographic profile of China

Population	1,439,574,949
Population Density	148 persons per sq. km
Median Age	38.4 years
Sex Ratio	104.6 : 100
Mortality Rate	7.1 deaths per 1000 population
Fertility Rate	1.6 children born per woman
Life Expectancy	76.4 years
%population > 65 years old	11.9%

Health expenditure per capita	$ 398.33
Income per capita	$ 9470
Out-of-pocket health expenditure	$143.04
Physicians per 1000 people	2
Nurses and Midwives per 1000 people	2.7

Source: https://www.statista.com/topics/753/china/, https://data.worldbank.org/

Health status

From 1990s onwards, China has undergone a dramatic change in terms of disease burden and healthcare. According to a study published in the Lancet [1], the rates of YLLs (Years of Life Lost), YLDs (Years Lived with Disability), and DALYs (Disability-Adjusted Life-Years) due to communicable, maternal, neonatal and nutritional conditions came down by a significant margin from 1990 to 2017. On the other hand, the same rates for non-communicable diseases increased during the given time period. This implies that the disease burden saw a shift from communicable to non-communicable diseases.

The leading causes of all-age DALY in 2017 were found to be Ischaemic Heart Disease and Stroke, as opposed to lower respiratory infections and neonatal disorders in 1990.

The observed burden implies that China has been more successful than would be expected, based on its Socio-demographic Index (SDI), in decreasing the health burden due to communicable diseases.

However, China has the largest number of Non-communicable Disease patients as well as deaths in the world.[5]

In China, healthcare seeking behaviours were primarily linked to the affordability of services. This along with accessibility, operational features of the system, and the patient's perception were important contributors to the overall translation of healthcare needs into demands.[16]

Structure of the Healthcare system

In the 1980s, China's economy shifted to become more of a market economy, i.e. role of the government in the economy decreased. Subsidies given to primary healthcare providers came down which led to these care providers starting to act like for-profit entities.

A common practice was primary doctor over-prescribing drugs and expensive diagnostic tests like MRI and CT-scan. There were two reasons for this – Firstly, the healthcare facilities were allowed a 15% profit margin on drugs, and Secondly, the income of healthcare professionals was linked to the revenue generated by the facilities they worked for.

This led to public distrust in the Chinese Healthcare system, leading to the healthcare reforms of 2009.

In this past decade, there are 5 major areas of healthcare reforms that the Chinese healthcare system has seen. These are in the areas of Social Health Security, Essential medicines, Primary healthcare, Basic Public Healthcare Service Package, and, Public Hospitals.

China has a 3-tier healthcare system both in the Rural as well as Urban areas.

In the Rural areas, healthcare organisations operate at the County, Township and Village level, and for the Urban centres, these three levels are the Municipality, District and the Community.

The public healthcare sector is the main healthcare provider. In 2017 [2], 82% of inpatient care was provided in Public hospitals and they account for 60% of the total health expenditure.

The out-of-pocket expenditure between 2000 and 2005, accounted for more than 50% of total health expenditure [3]. This figure declined to 28% by the year 2017.

Even the percentage of patients who needed hospital care but could not afford it declined from 17.6% in 2008 to 7.4% in 2013 [4].

Three basic insurance schemes operate in the Chinese Healthcare sector: The Rural and

COVID-19 in China

China changed the case definition for Coronavirus about 6 times during the course of the

China's National Health Commission on Feb. 12, re-categorized those patients who exhibited symptoms, as determined by a chest scan, as "confirmed cases" even without a positive lab diagnosis. They said this latest development applied only to the Hubei province, which was the epicentre of the outbreak.

On the 14th of February, the health commission made another move. It removed 108 deaths from the total count to correct some double-counting in Hubei province.

The change in case definition was taken differently by organizations and governments around the world. While the WHO said it was a step in the right direction and would make things clearer with regards to the actual threat of Coronavirus, many major powers across the world, including the USA, criticized China's actions and blamed them for not revealing their true numbers.

Table 1.2: Timeline of COVID-19 in China

December 31, 2019	Chinese authorities alerted the WHO about a pneumonia-like illness caused by an unknown virus in the city of Wuhan, Hubei province
January 1, 2020	The Huanan Seafood Market was sealed
January 11, 2020	The death of the first Chinese patient due to the novel viral infection was reported.
January 17, 2020	The 2nd Chinese death was reported
January 20, 2020	3rd death in China. With the approaching Lunar New Year holiday, and the confirmation of human-to-human transmission of the virus by a Chinese expert, fears rise.

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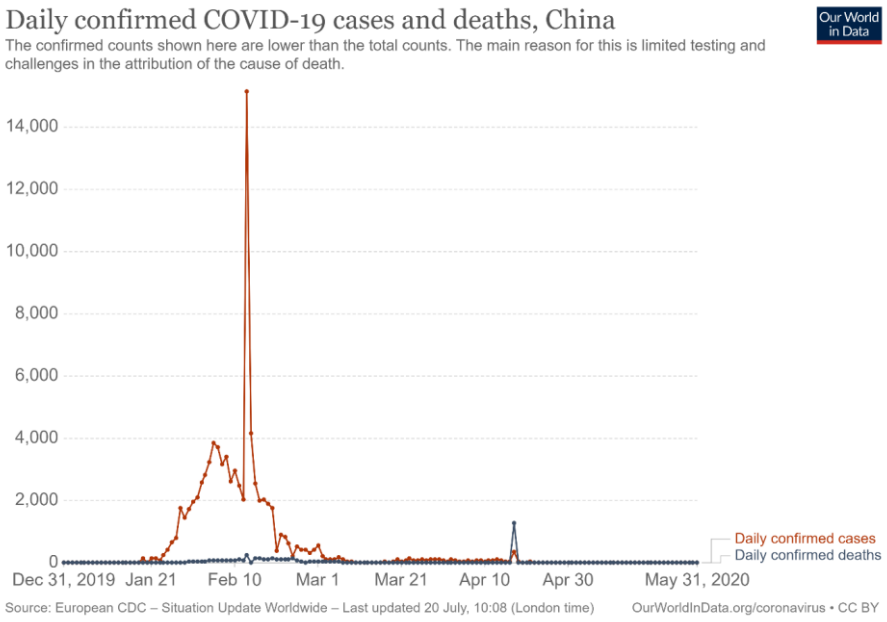
February 7, 2020	Li Wenliang, a Chinese doctor who was one of the first experts to warn against the potential threat of the novel Coronavirus, dies.
February 9, 2020	Death toll from the novel coronavirus surpasses that of the 2002-03 SARS epidemic. WHO sends a team of experts to China for assistance with management of this public health concern.
February 20, 2020	China's Health Commission reports a sudden dramatic increase in daily infection, reportedly due to the change in method of counting cases. While earlier, they were using molecular testing to identify cases, china changed its case definition to patients who have an established clinical diagnosis of the disease
March 7, 2020	The Health Commission reports 99 new cases, down from 143 of the previous day.
March 18, 2020	No new domestic cases in China reported for the first time since the outbreak
April 8, 2020	Wuhan begins allowing people to leave, after 76 days of restrictions and sealing off the city.
April 14, 2020	Taiwan reports no new cases for the first time since the beginning.

Figure 1: Total COVID-19 tests, confirmed cases, and deaths per million people in the China (up to May 31, 2020)



Management strategies

The initial Chinese response to the pandemic was seemingly sluggish and somewhat

To quote Tedros Adhanom Ghebreyesus, the Director-General of the WHO, he applauded the "speed with which China detected the outbreak" and "its commitment to transparency".
In the days leading to the official discovery of the existence of the Coronavirus, Dr. Li Wenliang, a 34-year old Ophthalmologist, was one of the first so-called 'Whistle-blowers'. In fact, on December 30, 2020, Dr. Li warned his fellow doctors in a group chat and suggested the use of protective clothing to avoid a SARS-like infection which he suspected. He was later investigated for spreading rumours and severely disturbing social order.

Once the virus had been detected, the government, as its initial measures:

- imposed a strict restriction on movement,
- mandated body temperature checks,
- logged the travel history of infected people.

Permits were issued, one per household, to go outside for any purpose.
Schools were shut down and online classes were organised to keep the education system running.
Essential items were delivered to households in a bid to keep households isolated.
Similarly, medicines were also delivered both to the hospitals as well as houses.

Telecom operators, like AliPay and WeChat, helped the government by tracking down people who had a positive travel history or those who came in contact with someone who did, and restricting their movement.
A Health Code System was established wherein a patient was given one of three-colour coding based on:

- Travel History,
- Time spent in hotspots
- Exposure to potential carriers.

Out of the three codes (Green, Yellow and Red – Green being the least likely to be infected), every person was assigned one code, which they then had to show the guards on duty at every checkpoint.
In some places, facial recognition software to identify people with a fever, or without a face mask, were also used.
In case of violation of any prevention and control measures, a 3+ years of punishment was put in place.

Apart from these social measures, China proactively built 2 hospitals – the 1000-bedded Huoshenshan Hospital and the 1600-bedded Leishenshan Hospital – in Wuhan, exclusively for COVID-19 patients, in a timespan of just over 1 week.
Furthermore, in Wuhan alone, 1800 teams consisting of 5-6 people each, traced thousands of contacts and built a strong database.
To fast-track the COVID-19 testing process, the National Medical Products Administration

Beijing Genomics Institute has also scaled up the production of its testing kits and donated them to Wuhan and established the Huoyan Laboratory, an emergency test laboratory that aims to speed up the testing of cases.

Major Chinese companies seem to have risen to the occasion and handled the crisis proactively. While some manufacturers set up makeshift assembly lines to produce masks

and disinfectants, other telecom companies joined hands with the government to monitor and surveil the population to limit physical interaction.

Alibaba was one of the major contributors to the management of this crisis. HEMA, the grocery chain under Alibaba, remained open and stocked without any price hike in the products being sold.

Alibaba Cloud offered free AI computing capabilities to public research institutions. This enabled viral gene sequencing, R&D of new drugs, and protein screenings.

Summary

Although China got off to a late start in terms of regulating the outbreak, they did manage to

China did earn some bad faith by changing their case numbers multiple times and not being completely transparent. This, again, has been a characteristic feature of the Chinese government. In this case, the world has been left perplexed as to the origin of the virus, and whether or not China could have done more to contain it.

However, the agility with which action was taken, for example building two hospitals of large capacity exclusively for COVID-19 patients within merely 10 days, was commendable. Prompt implementation of social distancing, quarantine and isolation, supported by heavy fines and punishment for those who broke the rules worked out well for the Chinese outbreak. The application of the same techniques in other countries with different social structures is debatable.

Country 2: U.S.A.

The U.S.A. has the highest health expenditure per capita across the world. Even so, the health system, is not among the top 10 globally, according to the WHO. Various attempts at a universal healthcare scheme have been made over the years, but none seems to have gained solid ground.

The COVID-19 outbreak started in the U.S.A. by the end of January. However, some experts are of the opinion that the virus was present in the American population much before that. Here, we study the American healthcare system, and how the country managed its COVID-19 outbreak.

Table 2.1: Demographic profile of U.S.A.

Population	331,002,651
Population Density	35.32/km^2
Median Age	38.2 years
Sex Ratio (male : female)	105 : 100
Mortality Rate	8.2 deaths per 1000 population

Fertility Rate	1.8 live births per woman
Life Expectancy	79.1 years
%population > 65 years old	15%
Health expenditure per capita	$ 10,246
Income per capita	$ 62850
Out-of-pocket health expenditure	$ 1094.55
Physicians per 1000 people	2.6
Nurses and midwives per 1000 people	14.5

Source: https://www.statista.com/topics/760/united-states/, https://data.worldbank.org/

Health status

In the United States, NCDs account for 89% of all deaths and have long surpassed infectious diseases as the main cause of death

U.S. prevalence is above average for four of the leading NCDs: cardiovascular diseases, cancer, chronic respiratory diseases, and mental health conditions

Mental and substance use disorders produce substantially higher DALYs across all NCDs in the United States than in other countries. Mental health conditions have a DALY rate of 3,725 per 100,000, which is 1.7 times the global average (i.e., 2,198 per 100,000), or 1.3 times the high-income average (i.e., 2,867 per 100,000)[7]

Coming to the cost, the U.S. is the highest health spender across the world. In 2017, about 10,246 USD was spent per capita on health (current health expenditure in purchasing power parity)[8]

This, however, does not ensure the best healthcare system. The outcomes from this system have not been among the best in the world.

According to a study, the costliest conditions in the U.S. are Mental health conditions and Cardiovascular diseases, followed by Cancer and Diabetes.

Our estimates indicate that the costliest conditions in the United States are mental health conditions and cardiovascular diseases, followed by cancer and diabetes.

In the United States, treatment costs account for 39% of NCDs' total economic burden. [9]

The healthcare seeking behaviour of the American population depends highly on a number of factors.

A survey conducted by Gallup, an American analytics and advisory company, presented certain facts about healthcare seeking behaviour of Americans and its relation to the cost of healthcare. They found that 25% of Americans said that they or a family member have delayed medical treatment for a serious illness due to the costs of care, and an additional 8% report delaying medical treatment for less serious illnesses.[10]

Another study showed an interesting finding. One of the greatest health disparities was seen in 12 states of the US. Two indigenous ethnic groups —American Indians and Alaskan

natives, were found to have a mortality rate from Influenza A/H1N1 fourfold higher than patients in all other ethnic populations combined.[11]

Structure of the Healthcare system

According to the Organisation for Economic Co-operation and development (OECD), in

Even so, about 8.5% of the American population went without a Health Insurance all-through 2018 according to a US Census Bureau report.

According to data from the American Health Association, health care facilities are largely privately owned and operated in the US. 58% of community hospitals in the United States are non-profit, 21% are government owned, and 21% are for-profit.

Figure 2: The Health Insurance coverage structure in the U.S.A.

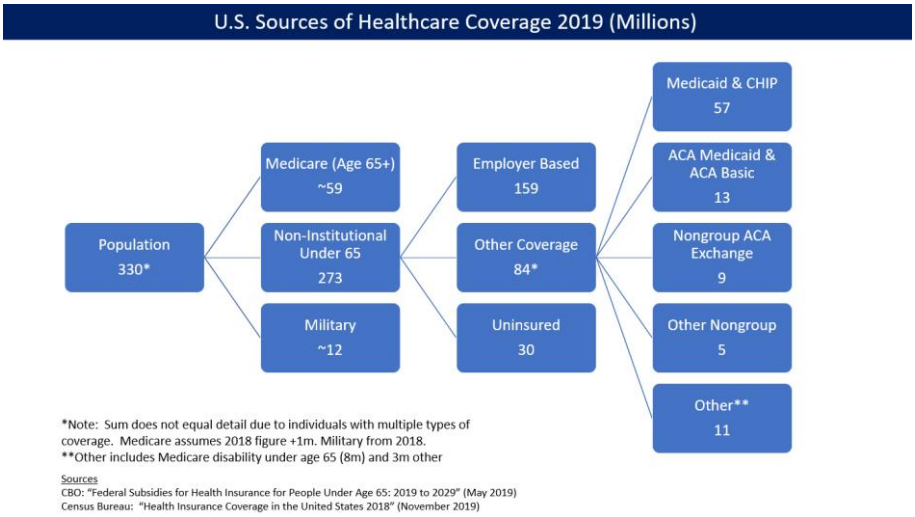


Table 2.2: Timeline of COVID-19 in the U.S.A.

January 6, 2020	Through a letter, and after being intimated about the situation of an Influenza-like illness in China, The Director of the CDC offered to send a team of CDC scientists to assist China.
January 8, 2020	The first Public alert for the Coronavirus was issued by the CDC.
January 17, 2020	the CDC dispatched public health experts to JFK, San Francisco, LA International Airports to screen arrival passengers.
January 20, 2020	First recorded US case of COVID-19 – An American citizen travelling from Wuhan, China to his home in Washington State. The CDC also developed a testing kit which was later found to be defective.

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January 30, 2020	First case of person-to-person transmission in Chicago.
January 31, 2020	COVID-19 declared as a public health emergency by the Trump Administration through the U.S. Department of Health and Human Services (HHS). In an action which was taken for the first time in the last 50 years, the U.S.A. denied entry to all non-U.S. nationals who travelled to China in the past two weeks. The administration also imposed a compulsory 14-day quarantine on any U.S. citizens who visited Hubei province in the past two weeks.
February 1, 2020	The HHS Secretary Azar showed concerns about shortages of medical equipment to combat the public health emergency in the U.S. A formal $4bn request was made which invited an outrage from the authorities.
February 5, 2020	The U.S. evacuated 345 citizens from the Hubei Province.
February 6, 2020	Another flight carrying 300 passengers was brought in. U.S. recorded its first COVID-19 death.
February 15, 2020	The Government evacuated 338 people from aboard the 'Diamond Princess' cruise ship off the shore of Yokohama, Japan.
February 26, 2020	First case of community transmission in California. However, it later became clear that community transmission had been ongoing since much before this time.
March 1, 2020	New York Governor Andrew Cuomo announced the first reported case of COVID-19 in New York. The number of conformed cases kept rising through the month of March.
April 16, 2020	Federal guidelines outlining a three-phased approach to reopen the economy and gradually restore commerce and services was were issued. Each phase was to last 14-days. However, this was only applicable in places where there was strong testing and the number of cases was decreasing.
April 30, 2020	Deaths – 60,996; Confirmed cases – 1.04 million
May 1-12, 2020	Some states like Indiana and Ohio start re-opening despite the high number of cases and deaths. Protests break out in Michigan over the governor's stay at home orders.

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May18, 2020	Governor Whitmer of Michigan announces the partial re-opening of some businesses by 22 May.
May 24-25, 2020	Smallest increase in cases and deaths since the beginning of May.
May 27, 2020	U.S. crosses the 100,000 mark of COVID-19 deaths.
May 28, 2020	About 40 million Americans had filed for unemployment.
May 31, 2020	Deaths: 103,781; Cases: 1.77 million

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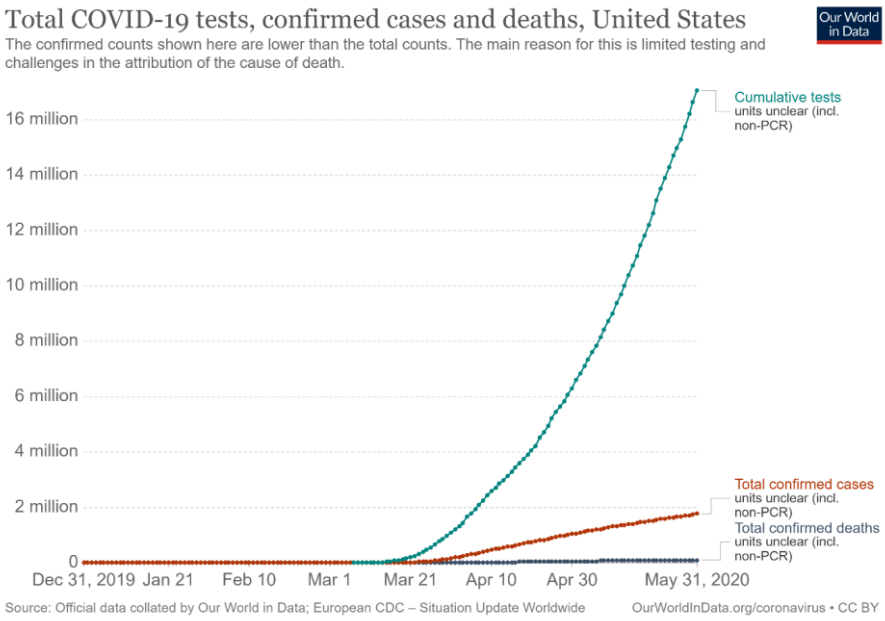
Figure 3: Total COVID-19 tests, confirmed cases, and deaths per million people in the United States (up to May 31, 2020)



Source: https://ourworldindata.org/coronavirus-data?country=~USA

Management strategies

By the end of February, the CDC came up with 160,000 tests, out of which only about 4000 were found to be accurate and fit for use. The tests developed by other academic authorities had to go through lengthy FDA approvals before they could be used.

The testing criteria initially stated by the CDC was that only a person who had symptoms and a travel history to Wuhan, China or if someone had come in contact with such a person, a test could be done.

By 1 February, the testing expanded to include travellers from Hubei province instead of just Wuhan in China and cases of respiratory illness severe enough to require hospitalisation along with a travel history to China.

During the same time period, 6 cities were selected for 'sentinel surveillance' to assess the extent of the disease. These were Chicago, New York, San Francisco, Los Angeles, Seattle and Honolulu as they were considered to be high risk areas.

California was the first to issue 'stay at home' orders, followed by other regions, much later.

By the end of February, the testing criteria were expanded to include travel history of China, Italy, Iran, Japan and South Korea, and people who had respiratory illness sever enough to require hospitalisation, without the condition of travel history.

By 5 March, testing criteria was further changed and discretion was given to the attending physician to make the call of whether or not a test was required. [19]

Very early on in the response to the outbreak, the government declared that there was a shortage of testing kits, and with this inventory, they would not be able to meet the predicted future demand.

All through the crisis, the outbreak was always several steps ahead of the authorities, which led to inaccurate databases.

Travel restrictions were put in place starting 1 February by Delta, American and United Airlines on all flights to and from China. However, Immediate family members of U.S. citizens and permanent residents were exempted from these restrictions. A 14-day quarantine was imposed on American Nationals returning from the Hubei Province, China.

By mid-March, the government came up with the "15 Days to Slow the Spread" which were a series of CDC guidelines to slow the spread. Alongside, states were also advised to close down schools and avoid gatherings of 10 or more people.

The National Guard was deployed in the states of New York, California and Washington in March-end. For isolation of patients, the city of Chicago announced that it would rent hotel rooms.

The USNS Mercy and the USNS Comfort (two Navy Hospital Ships) arrived at the coasts of Chicago and New York respectively, to assist with the containment efforts.

Summary

For a very long period, the United States authorities kept denying the existence of the virus in

In terms of management, there was lack of a unanimous approach across various states. While some states implemented quarantine and social distancing, others did not. Travel restrictions were also not country-wide leading to spread of the virus.

There was a steep rise in unemployment due to the lockdown in various states. This led to an increased economic burden which is expected to surface once the pandemic is over[32].

The overall response of the Unites States has been callous and the price has been the largest number of deaths across the world.

Country 3: South Korea

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A small East Asian country, South Korea boasts of high technological advancements. This strength is applied by the country in its healthcare as well. Even during the COVID-19 outbreak, as discussed later, the effective use of technology played a vital role in managing the crisis in an exemplary way.

Table 3.1: Demographic profile of South Korea

Population	51.64 million
Population Density	514 per km sq.
Median Age	43.7 years
Sex Ratio	100.4 (male to female)
Mortality Rate	6.31 per 1000 population
Fertility Rate	1.05 children per woman
Life Expectancy	82.63 years
%population > 65 years old	14.42%
Health expenditure per capita	$32000
Income per capita	$ 30600
Out-of-pocket health expenditure	$ 680.81
Physicians per 1000 people	2.4
Nurses and midwives per 1000 people	7.3

Source: https://www.statista.com/topics/4944/south-korea/, https://data.worldbank.org/

Health status

In 2015, the total socioeconomic disease burden in Korea was an estimated USD 133.7 billion and 9.7% of gross domestic product (GDP); of this, USD 65.5 billion and USD 68.2 billion were attributed to direct and indirect costs, respectively. Non-communicable diseases accounted for the majority (69.1%), with cancers accounting for 15% of the overall disease burden.
Men accounted for 61% of the economic disease burden, while women accounted for 39%.

These findings indicate that a high percentage of the total socioeconomic disease burden in Korea is due to chronic diseases, such as cancer and cardiovascular diseases. However, infectious diseases, injuries (in particular, self-harm), and LBP are high in specific age groups.[12]

The NHIS covers almost 97% of the population as a single insurer.[13]

It has also been found that the rate of preventable hospitalisations of Medical Aid patients was higher than that of the NHI patients (and statistically significant).[14]

According to Organization for Economic Cooperation and Development (OECD) statistics, the per capita doctors' consultations in Korea were 16.0, the highest among OECD countries.[15]

Structure of the Healthcare system

I. National Health Insurance Program
II. Medical Aid Program
III. Long-term care Insurance Program

The insurance system is funded by contributions, government subsidies, and tobacco surcharges and the National Health Insurance Corporation is the main supervising institution. Per 1,000 patients, S. Korea has 2.34 doctors.

Table 3.2: Timeline of Covid-19 in South Korea

January 20, 2020	The first case of COVID-19 in South Korea was a 35-year-old Chinese woman.
January 23, 2020	The first South Korean national infected with COVID-19, 55-year-old man who worked in Wuhan.
January 30, 2020	The 6th case was the first case who did not have travel history abroad.
February 16, 2020	The toll of infections reached 30 after which the number of cases exploded. This happened through Patient 31, who is now being called the 'Super-Spreader' of COVID-19 in S.Korea. Patient 31 was a 61-year-old woman, who was a congregant at the Shincheonji Church of Jesus in Daegu
February 20, 2020	the first COVID death was reported. Cases continued to rise all through March.
March 8, 2020	KCDC announced that 4482 confirmed cases were traced back to the Shincheonji Church, accounting for 62.8% of the total confirmed cases.

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April 17, 2020	KCDC announced that 163 people who had recovered from the virus had been tested positive again. The reason was not clear.
April 18, 2020	New cases reached the single digit mark.
April 30 – May 1, 2020	A 29-year old said to have visited 5 nightclubs in one night was tested positive in Seoul. All contacts, amounting to more than 1300 people, were told to self-quarantine for 14 days. Following this, bars, clubs and salons were put under lockdown until further notice.
May 10, 2020	About 79 people had tested positive in relation with the clubs in Itaewon. It was unclear whether or not the country had been hit by a second-wave of the outbreak, even until the end of May.

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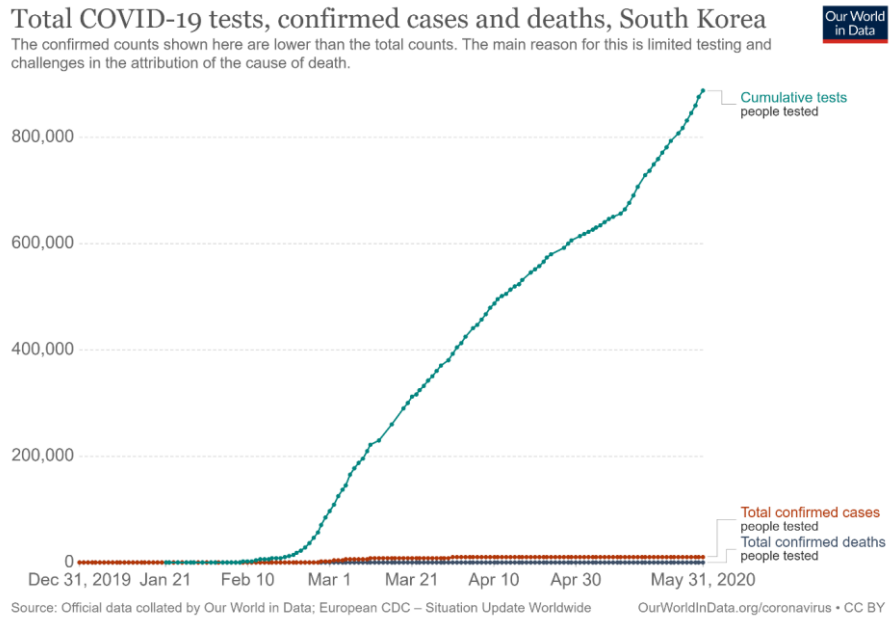
Figure 4: Total COVID-19 tests, confirmed cases and deaths in South Korea (up to May 31, 2020)



Source: https://ourworldindata.org/coronavirus-data?country=~KOR

Management strategies

In late February, South Korea became the second highest COVID-19 hit country after China. From the start, the strategy remained focussed on proactive testing and contact tracing. After the cases exploded following Patient 31 who later came to be known as the Super-spreader, active steps were taken to flatten the curve.

Firstly, since S. Korea had already experienced the MERS outbreak in 2015, the system and protocols were ready for rapid response to handle another similar outbreak.

A lockdown was not enforced, although all schools were shut down in anticipation of a greater spread of the virus.

The Healthcare system was re-organized to minimize person-to-person infections in hospitals.

A clear system was put in place. Depending on the severity of symptoms, the following measures were taken:

1. If an individual experienced symptoms of COVID-19, they were advised to call the Public Helpline Number and get an initial assessment over the phone.
2. If that person was suspected to be infected, they were directed to a nearby testing facility.
3. Hereafter, if they were tested positive, they were put under quarantine.

Drive-through testing sites were prepared, which reduced the risk of people coming in contact with each other, ensuring social distancing.

To reduce the burden on the public, the government covered all medical costs associated with COVID-19 for citizens as well as foreigners.
Additionally, paid leave was given to all infected patients, and basic living expenses were issued to the unemployed population.

With the use of technology, through Smartphones and Credit Cards (which nearly all citizens use), Contact tracing was made extremely effective. Direct contacts of infected people were tested compulsorily, and Indirect contacts were placed under self-quarantine for 14 days.

Using the same technology, the government also assured that people were abiding by the rules of quarantine and staying in.

The supply of masks was initially deficient. To cover this gap, the government asked companies to ramp up production. Simultaneously, to keep people from hoarding masks, only a limited number of masks were sold to every citizen. This was tracked by the National Health Insurance Service Database. Apps were developed to assist people by displaying the number of masks available at nearby locations.

Summary

South Korea has been a shining example to the world in terms of managing the COVID-19 outbreak. This can be attributed to the fact that they already had experience with a similar

situation during the MERS outbreak of 2015. The country used focused SOPs (Standard Operating Procedures).

From social distancing and quarantine, to extensive contact tracing and the effective use of technology, S. Korea managed to flatten the curve in a short span of time.

Some experts are of the opinion that such measures are difficult to implement in a country with a larger population, a weaker healthcare system, or even a lack of technological advancements to this extent, among other things (e.g., India).

Regardless, S. Korea's management has become a model which is being studied across the globe.

Country 4: Italy

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Italy, a South-central European country, has the second-best health system in the world, according to the WHO. Italy also has one of the world's oldest populations, which presented as a unique type of problem during the COVID-19 outbreak in the country.

Table 4.1: Demographic profile of Italy

Population	60,461,826
Population Density	205.45 persons per km sq.
Median Age	45.7 years
Sex Ratio	0.93 male to female
Mortality Rate	10.66 per 1000 population
Fertility Rate	1.34 births per woman
Life Expectancy	83.2 years
%population > 65 years old	23.1 %
Health expenditure per capita	$2738.71
Income per capita	$ 33540
Out-of-pocket health expenditure	$ 632.92
Physicians per 1000 people	4
Nurses and midwives per 1000 people	5.8

Source: https://www.statista.com/topics/2504/italy/, https://data.worldbank.org/

Health status

According to the Country Health Profile 2019 by the WHO, higher education and being of the female sex are two characteristics that have been found to be associated with a longer Life Expectancy(LE) – women live about 4 years more than men on an average, and highly educated Italians (beyond secondary education) is approximately 4[17].
The general disparity in socio-economic status among the Italian population is one of leading reasons of the difference in Healthcare seeking behaviour.

The education gap in life expectancy is 4.5 years for men and about 3 years for women, i.e. Women with lower education (ones who have not completed secondary education) live 3

years less than women with higher education (ones who have completed tertiary education) on an average at the age of 30 years. For men, the same gap is 4.5 years.

Cardiovascular Disease (in particular, Ischaemic Heart Disease and Stroke) remains the main cause of death in Italy since many years now.

According to the Population Reference Bureau (PRB), Italy houses one of the world's oldest populations. Over 23 percent of the Italian population is above the age of 65 years.[18] Out of these, only 52% have been vaccinated against Influenza, a number which is well below the WHO recommended 75%.

According to estimates, behavioural risk factors like dietary factors, tobacco smoking, low physical activity and alcohol consumption led to one-third of all deaths in Italy in 2019.[17]

Generally speaking, Northern and Central regions of Italy have more advanced medical and diagnostic technology, more capacity, and better perceived quality of care. This translates to an increased flow of patients in these regions compared to the South.

Data from the Ministry of Health shows that southern regions of Campania, Calabria, and Sicily lose about 30,000 patients every year due to lack of healthcare facilities.

Another interesting fact is that the number of acute care hospital beds has decreased by about 30% (between the years 2000 and 2017) to 3.2 beds per 1000 population.[17] This is due to adaptation of the healthcare system to the changing health needs of the population, like geriatric care.

A striking statistic shows that one-third of all EU deaths due to microbial resistance happen in Italy. With respect to COVID-19, a theory that is being contested on the number of deaths in Italy is that a viral infection can pave way for a secondary bacterial infection, which in turn can cause complications like bacterial pneumonia, a fatal condition.

Structure of the Healthcare system

According to the WHO, the Italian Health System is said to be the second-best in the world.

Italy has a decentralised Healthcare system, which operates on 3 levels:
1. State Health Board
2. Regional Health Board
3. Local Health Board

The State Health Board has the responsibility oversee work contracts, issue general guidelines, finance research projects, and maintain International Relations.

Italy consists of 20 regions, each of which have their own Health Authority. This regional office finances independent hospitals and presides over the functioning of the health services in that region.

The Local Health Authorities (approx. 200 in number) are responsible for the daily management of health services. They finance those public and private hospitals which are

under contract with these authorities (Most private hospitals are under contract with these regions).

The rest of the private hospitals are financed by their patients.

It is not uncommon for Public hospitals to engage in private activities as they are for the most part independent hospitals.

A cap has been put in place for the number of patients each doctor is allowed to cover. The number stands at 1800 for a general practitioner and 800 for a paediatrician.

A key component of the Italian Healthcare system is the National Electronic Healthcare Card. This was launched in 2005 and provided to almost 15 million Italian citizens and residents. It keeps a track of each phase of the public health expenditure cycle, along with the patient's medical information and European Health insurance information.

The Italian National Health Service, established in 1978, is a universal public health service, financed by general taxation. It provides free healthcare to all Italian and EU citizens at the point of delivery.

There are 4 doctors for every 1000 people, which is among the highest in the world. There is, however, a shortage of nurses. Italy has 5.8 nurses for every 1000 people which is well below the EU average of 8.5. [17]

National Health Plan or the *Servizio Sanitario Nazionale (SSN)* is the Public Health Insurance Scheme in Italy. Under this plan, all citizens and legal residents of Italy are covered, which includes citizens of US and Canada, who are legal residents of Italy.

Private Insurance Providers are not very common, and mostly exist only to fill the gaps in the Public Insurance Scheme, i.e. act as a supplement rather than a replacement for the Public Insurance already provided.

Table 4.2: Timeline of Covid-19 in Italy

January 31, 2020	First two cases of COVID-19 were confirmed in Rome. This was a Chinese couple who had travelled from Wuhan. On the same day, all flights to and from China were suspended and a state of emergency was declared in Italy. Thermal scanners were put in place at international Airports.
February 6, 2020	An Italian, who travelled from Wuhan recently, was tested positive.
February 22, 2020	The third case was discharged, along with the Chinese couple within the next 4 days.
February 19, 2020	the UEFA Champions League match was held at San Siro in Milan. This was later said to be the "game zero" as 40,000 people attended this gathering.

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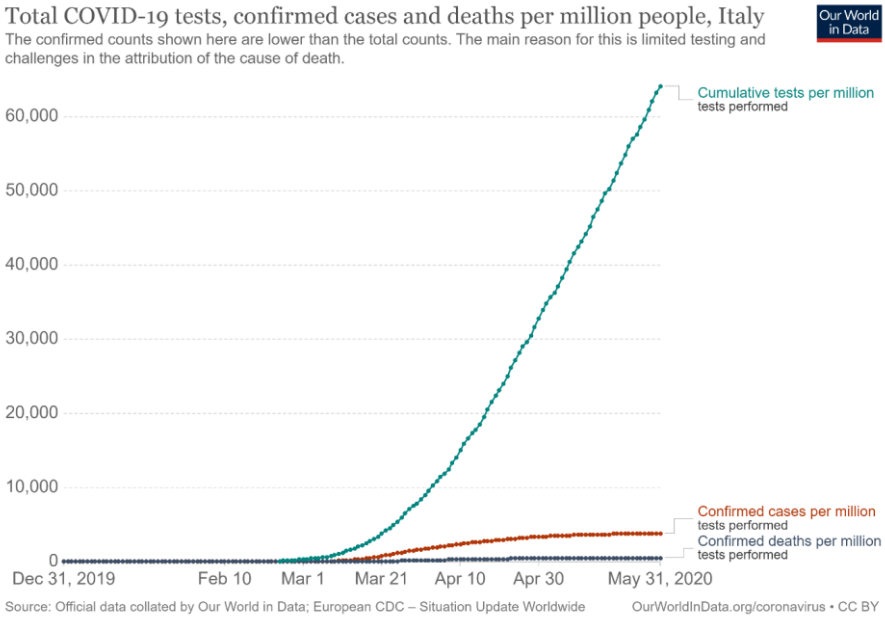
February 20, 2020	A young man in the Lombardy region of Italy was admitted with an atypical pneumonia that later proved to be COVID-19. In the next 24 hours there were 36 more cases, none of whom had contact with the first patient or with anyone known to have COVID-19. This was the beginning of one of the largest and most serious clusters of COVID-19 in the world.
February 22, 2020	A 78-year-old man died in Monselice, making him the first COVID fatality in the country. A 77-year-old woman, who suffered from pneumonia, died in Lombardy. The Lombardy cluster kept growing at a rapid pace.
March 8, 2020	The Prime Minister Giuseppe Conte put the region of Lombardy and 14 other provinces in the north under quarantine lockdown.
March 10, 2020	Quarantine lockdown was extended to cover all of Italy. This came along with a ban on public gatherings and travel restrictions.
March 18, 2020	An Italian group for Evidence-based medicine, GIMBE, found that 8% of all detected coronavirus cases were those of healthcare workers.
March 24, 2020	The province of Bergamo had become the hardest-hit province in all of Italy. 7000 people had tested positive and about 1000 had died of COVID-19.
April 5-6, 2020	There was a decrease in the deaths and new cases per day for the first time in two and a half weeks.
April 20, 2020	There was a fall in the number of active cases.

Figure 5: Total COVID-19 tests, confirmed cases and deaths per million people in Italy (up to May 31, 2020)



Source: https://ourworldindata.org/coronavirus-data?country=~ITA

Management strategies

One of the first measures that the Italian government took was to demarcate 11 municipalities in Northern Italy as 'red zones'. This meant that there was a complete lockdown in these areas, and over 50,000 people were told to quarantine within their residence. Lombardy and Veneto were the hardest hit regions.

The areas outside the red zones were called yellow zones, where the restrictions were a little less severe.

Penalties from about 200 euros to three months imprisonment were put in place for violations of the rules of quarantine.

Schools in various hard-hit regions were shut down. Trains to the red zones were suspended, along with religious services and public gatherings.

Instead of flocking at hospitals and increasing the risk of spread, people with symptoms were told to call the 112-emergency number. More numbers were added subsequently for particular regions.

By the end of February, the Director of the Italian National Institute of Health, Franco Locatelli, announced that only symptomatic patients would be tested. This move came as a result of the previous statistics which said that 95% of the swabs tested negative.

The Veneto region, which took up the blanket testing approach, would later be known to perform better in the management of COVID-19, than Lombardy, where symptoms preceded testing.

On 11th March, 25 billion euros were allocated for the emergency.
An economic stimulus of 200 billion euros for state-guaranteed loans and 200 billion euros of export guarantees was announced by the government.

During the peak of the outbreak in Italy, masks and other safety equipment were in scarce supply.
By mid-March, the German government agreed to send one million masks to Italy.
A team of Chinese experts who had gone to Italy to offer their expertise in the management of the outbreak also contributed by bringing respiratory devices, masks, ventilators and other equipment along.

Cuba, Albania, Somalia, Serbia and Russia were among some of the countries which sent medical help to Italy, along with supplies from some.

Companies like Ferrari, Grafica Veneta, Ci.Ti.Elle, and others used their resources to produce masks and protective equipment in bulk.

Summary

Italy was one of the hardest hit countries across the world. Even with an excellent healthcare system, second only to France, Italy struggled with containing the outbreak. Some of the leading causes of this scenario that come to light are the larger percentage of geriatric population, the lack of acute care beds in Italian hospitals, and a delayed administrative response.

The response of the administration was not the quickest, which led to a sudden and dramatic increase in cases. Some regions like Lombardy, in particular, were gravely affected.

Country 5: India

India's COVID-19 struggle has seen a slightly delayed timeline, mostly due to the nationwide lockdowns. With the second-largest population in the world, India faces a very unique and dangerous challenge at its hands.

Table 5.1: Demographic profile of India

Population	1,380,004,385
Population Density	460 persons per km^2
Median Age	28.4 years

Sex Ratio (males to females)	109:100
Crude Death Rate	7 deaths
Fertility Rate	2.2 live births per woman
Life Expectancy	70.4 years
%population > 65 years old	6.2%
Health expenditure per capita	$ 62.72
Income per capita	$ 2020
Out-of-pocket health expenditure	$ 40.51
Physicians per 1000 people	0.9
Nurses and midwives per 1000 people	1.7

Source: https://www.statista.com/topics/754/india/, https://data.worldbank.org/

Health status

India is the second most populated country in the world after China, currently standing at about 1.3bn. 68.86% of this population lives in the rural areas of the country.[35]
Out of the rural population, 25.7% live Below Poverty Line (BPL), whereas 13.7% of the Urban population lives Below Poverty Line.
According to the National Health Profile 2019, published by the Central Bureau of Health Intelligence (MoHFW, GoI):

- Acute Respiratory Infections and Pneumonia accounted for 27.21% and 30.65% of the deaths due to communicable diseases respectively, in the year 2018.
- Acute Respiratory Infections accounted for 69.47% of the morbidity reported in Communicable diseases.
- 70% of the world's malaria cases come from India.
- Out of nearly 6.5 crore patients who attended NCD (Non-communicable disease) clinics, 4.75% people were diagnosed with Diabetes, 6.19% with Hypertension, and 0.30% with Cardiovascular diseases.

India's healthcare workforce density (including doctors, nurses, midwives) in 2016 was reported to be 20. 6 per 10,000 population, compared to the WHO recommended figure of 22.8.[33]

Structure of the Healthcare system

In 2000, the Government of India in its ongoing policy changes under the broader Liberalisation, Privatisation, and Globalisation plan, opened up the insurance sector to private players.
In the fiscal year 2016-17, 34% of the population was covered under any health insurance, out of which 79% are covered under public health insurance plans.
Government insurance schemes provided at both central and state level are:

1. CGHS (Central Government Health Scheme) –
2. ESIS (Employee State Insurance Scheme) –
3. RSBY (Rashtriya Swasthya Bima Yojna) –
4. Other Schemes:

I. Health Minister's Discretionary Grant (HMDG)
II. Rashtriya Aarogya Nidhi (RAN)
III. Health Minister's Cancer Patient Fund within RAN
IV. State-run health coverage schemes (e.g.: Yashaswini in Karnataka)

Private spending is shockingly high — out of pocket expenditure is a whopping 70 percent of total spending. – WHO

Table 5.2: Timeline COVID-19 in India

January 30, 2020	A student from the Wuhan University returned to Thrissur, Kerala, and was the 1st recorded COVID-19 case in India.
January 31, 2020	India first airlifted its citizens from China.
February 2-3, 2020	Two students who returned from Wuhan to Alappuzha and Kasaragod districts respectively. Kerala government, hereafter, declared coronavirus as a state calamity.
February 4, 2020	Visas for all Chinese and foreigners who had a travel history to China in the last two weeks were cancelled.
February 27, 2020	India conducted its final airlift from China and 7 the countries.
March 2-3, 2020	2 more cases, one in Delhi who had travelled to Italy and back and one in Hyderabad who had returned from the UAE tested positive for the virus. An Italian citizen who had earlier tested negative, was found to be COVID-positive. Contact tracing of all three individuals was done and several people including flight attendants and hotel staff who came in contact with these patients were quarantined.
March 4, 2020	Total cases reached 29, after associates of the Italian tourist tested positive along with contacts of other COVID-positive individuals.
March 6, 2020	Screening begins at all International Airports as opposed to the earlier strategy of testing only passengers from 'high risk countries'.
March 9, 2020	Maharashtra reported its first two cases in Pune – a couple with a travel history to Dubai.
March 12, 2020	India recorded its first COVID death who was a 76-year old man from Karnataka who had a travel history to Saudi Arabia.

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	The entry of foreigners into India was banned for a month – Upto April 15. Haryana declared COVID-19 as an epidemic after the case count reached 14.
March 13, 2020	Odisha declared COVID-19 as a 'disaster' even though the state had not reported even a single case. All educational institutions, public swimming pools, cinema halls and gyms were closed.
March 16, 2020	All gyms, spas, night clubs and theatres were closed uptil March 31 in the national capital Delhi.
March 20, 2020	The ICMR (Indian Council of Medical Research) changed the case definition. COVID testing now be done in symptomatic cases irrespective of the travel history or a contact with travel history.
March 22, 2020	A 14-hour long voluntary 'Janata Curfew' was observed all over India. The government announced that Indian Railways would suspend all passenger trains up to 31 March.
March 25, 2020	A nationwide lockdown was announced till April 14.
March 31, 2020	The Nizamuddin area emerged as one of the COVID-19 'hotspots' in the country. This happened after hundreds of devotees at a religious congregation (Markaz) at the Tablighi Jamaat, and were tested positive for the virus
April 2, 2020	129 cases in Delhi and 74 in Tamil Nadu were linked to the Delhi congregation. 9 people died in Telangana all of whom had attended the congregation.
April 14, 2020	the total cases rose to 10,000, and the lockdown was extended uptil May 3.

THE LOCKDOWN:
India has the second largest population in the world, which amounts to about 130 crore people. This entire population was put under a strict lockdown, which consisted of four phases:

Lockdown 1:
Started on 25 March and extended until 14 April.
Rate of growth of COVID cases had significantly slowed down. From a case doubling rate of 3 days, it now came to 8 days.

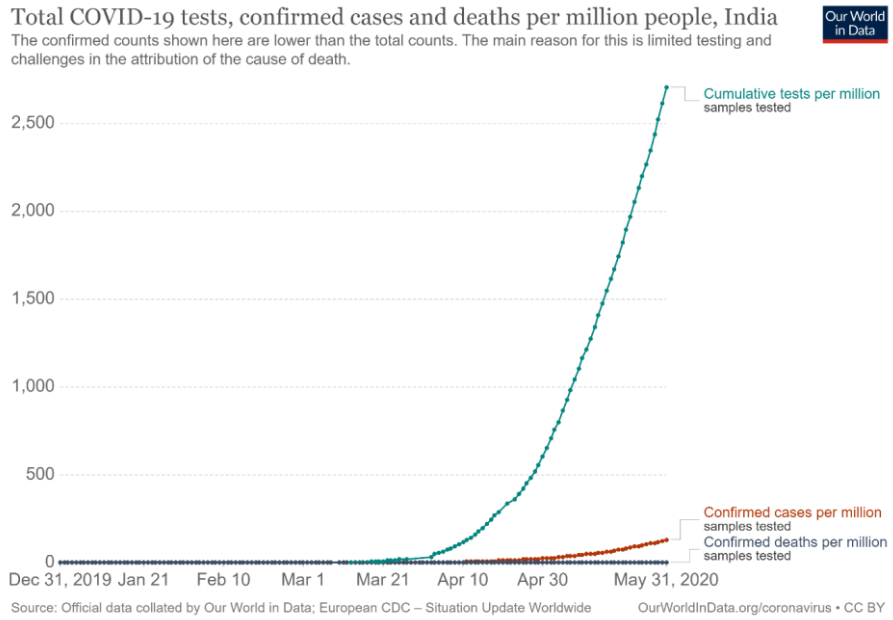
Lockdown 2:

The first leg of the lockdown was extended until 3 May.
Conditional relaxations were given, after 20 April, to some areas which had managed to contain the spread.
On 16 April, various zones were demarcated according to the spread of the disease in that particular area.
The 'red zones' were those with a large number of Coronavirus cases, along with a high doubling rate.
The 'orange zones' were areas with a comparatively smaller number of cases.
The 'green zones' were areas where no new cases had been reported in the last 21 days.

Lockdown 3:
Further extension of the lockdown period up to 17 May was done with some exceptions to the rule.
The country had been fully divided into three zones by now.
Public transportation was allowed to run at 50%capacity in green zones.
Private or hired vehicles could operate within orange zones.
Red zones were to remain under complete lockdown.
This classification was to be revised once a week.

Lockdown 4:
A further extension of two weeks was done.
Red zones were further divided into 'Buffer zones' and 'Containment zones', which were demarcated by the local authorities.
This lasted till 31 May.

Figure 6: Total COVID-19 tests, confirmed cases, and deths per million people in India (up to May 31, 2020)



Source: https://ourworldindata.org/coronavirus-data?country=~IND

Management strategies

Initially, when there were just a single-digit number of cases across the country, the Government of India maintained the stance that COVID-19 was not an emergency situation in the country.
Later, however, with an increase in cases and with the incidence rate increasing every day, a sequence of steps was taken:

- Visas of all foreigners were cancelled.
- Contact tracing of the cases with travel history to 'High risk countries' was done.
- Screening of passengers began by the first week of March.

India later banned the entry of any foreigners up to mid-April.

From 25 March onwards, the world's largest lockdown was put into effect, initially until 14 April, but later extended to 31 May.

The 'Aarogya Setu' application was created by the National Informatics Centre under the Ministry of Electronics and Information Technology (MeitY).
This app uses a device's GPS and Bluetooth features to track and trace COVID-19 infections.

Public awareness campaign was also launched, including coordination with telecom operators. An awareness message about coronavirus and the precautions that need to be taken was mandated before every phone call.
Big brands partnered with their brand ambassadors and celebrities to spread messages about social distancing, the use of masks and hand washing.

In some states like Rajasthan, door-to-door awareness through banners and pamphlets distributed by Anganwadi workers, ASHAs, local public representatives, ANMs, etc.

Testing:

The approach taken by India was that of cluster containment. During the initial days, testing was done only in people who had travel history to any of the 12 high risk areas put forth by the authorities, or if they had contact with someone of a similar travel history, or if a person is showing symptoms of the infection as stated by the government.

By mid-March the government changed testing criteria to include all pneumonia cases, regardless of the travel history. This came as a response to the steep upward curve of cases in the country.

By the end of March, ICMR advised the use of hydroxychloroquine, a drug used to treat Malaria, as a precaution for high-risk professions like doctors on duty.

A low-cost paper-strip test was developed by the Institute of Genomics and Integrative Biology of Delhi in April. It could detect the virus within one hour, and cost around ₹500 (US$7.00).

By mid-April, the state of Uttar Pradesh and the Union Territory of Andaman and Nicobar Islands switched to pooled testing. Under this, a pool of samples were tested together and individual tests were done only if the pool tested positive. This helped in increasing the testing capacity.

On 16th April, China dispatched rapid antibody test and RNA extraction kits to India. However, soon after, these kits were found to be faulty and imprecise. Following this, ICMR advised all states to stop using these kits.

To make up for the shortage of masks, ventilators, PPE kits and other safety supplies, many PSUs used their production lines for this purpose. This included DRDO, ISRO, Maruti Suzuki and many other public organisations. This led to India becoming the second largest producer of PPE kits after the mid-May.

Bhilwara Model[24,25]: From being the first district in Rajasthan to report the highest number of cases, Bhilwara (a textile hub) set a model in terms of Coronavirus containment strategies, the replicability of which is being discussed to extrapolate to the whole country.
The first case was a doctor in a private hospital which became the epicentre of the outbreak in this district. The number of cases shot up within a few days.
Following this, the district administration too "ruthless containment" measures. With the help of the Health department, 850 teams were assembled, which were deployed all over the area to carry out house-to-house surveys of 56,025 houses, i.e., 2,80,937 people.
Out of these 2250 people were found to have an Influenza-like Illness (ILI), all of whom were immediately put under strict home quarantine. Contact tracing was done for all these patients, and a list of 498 people from 5 other states was prepared, who had come in contact with the potentially infected patients. Official estimates suggest that in 5 days, about 30 lakh people were surveyed.
The borders of the district were sealed for all private vehicles. Trains through Bhilwara were instructed not to stop anywhere in the district.
The district collector Mr. Rajendra Bhatt ensured that the whole district was under lockdown by imposing Section 144 CRPC , and even groceries were being supplied to each household via the police.

Kerala Model[26,27]: The state of Kerala had seen a similar outbreak situation with the Nipah virus in 2018. The administration applied a lot of the learned techniques to the present outbreak and got excellent results. Despite being decentralised, the healthcare system of Kerala, which is one of the finest in the country, worked in tandem, like a well-oil machine. The district of Pathanamthitta was a striking example.
Kerala was the first state to report a case of COVID-19 in India. Until March 26, Kerala had recorded the highest number of positive cases in the country, followed by Maharashtra. In the Pathanamthitta district, along with contact tracing and borders being sealed, technology took the front seat. Every person who entered the district was screened and a database was created based on this, so that these people are easily reachable later on, if need be. Graphics were also created to show the travel routes of positive cases. These graphics were circulated in the community, leading to increase in self-reporting. Teams were appointed to keep a check on the people who entered the district before it was sealed.
An app called Corona RM, designed by the engineering students of IHRD College, Chengannur, to detect people who broke the home quarantine protocols, through GPS.
Within 6-10 days the number of new cases fell to single digits.

Summary

India's COVID-19 curve has seen a shift due the country-wide lockdown imposed by the central government. On May 31, 2020, the 4th lockdown ended. The purpose of the lockdown, as explained by the authorities, was to build capacity of the healthcare system to handle a tsunami of cases as and when the lockdown is opened. This meant manufacture of ventilators, testing kits, masks, PPE kits, and other safety equipment, along with development of the infrastructure to bear the immense patient load.

Testing is one area where India has been lagging. However, the mortality rate of the Indian population seems to be lower compared to the world average. This can be attributed to the fact that 20% of the Indian population consists of youths (15-24 years of age), compared to just about 6% who are above the age of 65 years. Along with this, data also suggest that rural India is less affected than urban areas[31]. And since 70% of the population in India lives in rural areas, this an advantage for the country.

Studies are still being conducted to understand the low COVID death rate in the country.

Discussion

A comparison between SARS-CoV-2 and previous pandemics shows that no straightforward similarities in management can be established, mostly because of the unique nature of this novel virus. Due to asymptomatic cases being infectious, the novel Coronavirus has brought us into virgin territory.

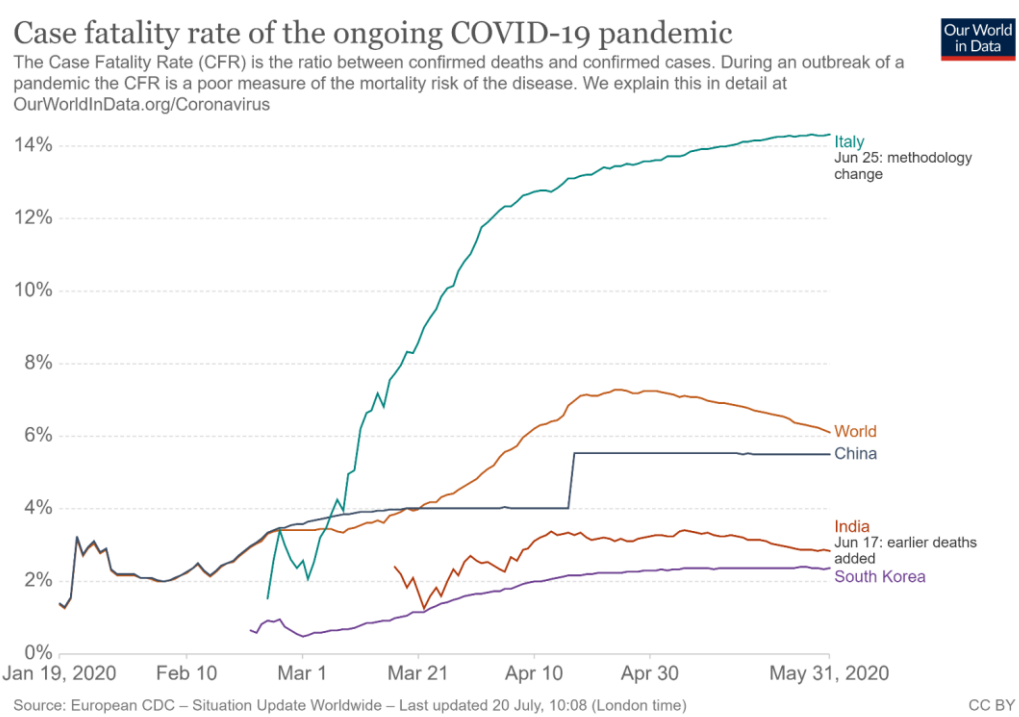
The WHO's 'test, trace, isolate, treat' approach seems to be working in the parts of the world which have been able to follow it diligently. A good example of this is South Korea, where the administration was always one step ahead of the virus. Testing and contact tracing were extensively undertaken. The use of technology to track cases, or to keep a check on cases in home quarantine, has also been a game-changer (Kerala, South Korea).

The reason that one of the best health systems in the world – Italy's NHS – was overwhelmed can be traced back to not enough testing early on in the outbreak, as well as a unique demographic profile of the country (large percentage of older adults).

Some management strategies like that of China or, on a smaller scale, Bhilwara (Rajasthan, India), take the radical way – a curfew for as long as the R_0 doesn't drop below one. However, various factors come into play in the implementation of such plans. For one, China's Authoritarian Government supports the use of force to bring about law and order. As for Bhilwara, it was a geographically a very small area as compared to the size of a country. Extrapolating these aggressive strategies without the political, social, economic, and financial structure to back it is not an option.

The legitimacy and necessity for India's nation-wide lockdown is still being studied. A clear picture will likely develop as and when more data becomes available for extensive research on the topic.

Figure 7: Case Fatality Rate Trends in Italy, India, South Korea, and China for the COVID-19 pandemic (up to May 31, 2020)



Source: https://ourworldindata.org/coronavirus-data-explorer?hideControls=true

Conclusion

USA, the highest heath spender of the world, still struggles to get a hold on the Coronavirus crisis. On the other hand, India, which has one of the lowest expenditures on health compared to all its contemporaries, has been found to have a strikingly low death rate, which might be due to its youthful population, among other factors.

Countries with a universal healthcare schemes, like South Korea and Italy, have seen drastically different COVID-19 trajectories. This can be owed to a number of reasons. For one, Italy has a high percentage of aged people, who seem to be the prime fatalities of the Coronavirus infection. Secondly, South Korea, which went through a similar situation with the MERS outbreak, has pre-determined SOPs (Standard Operating Procedures) to deal with a nationwide health crisis.

When we compare the Doctor to population ratio in the countries being studied, Italy leads (4/1000), and India trails (0.9/1000), both by a huge margin. Similarly comparing the Nurses

and midwives to population ratio, U.S.A. tops the charts (14.5/1000), while India, again, lies at the bottom (1.7/1000). Yet, interestingly, these figures have not been a testament to the performance of either of these countries in the ongoing COVID-19 pandemic.

The Case Fatality Rate (CFR) turned out to be the highest in Italy (14.3) as on May 31, 2020. South Korea (2.4) and India (2.8) showed a dramatically low CFR compared to the other countries under study.

Among the common strategies adopted by all 5 nations were social distancing, wearing masks, complete or partial travel restrictions, and quarantine measures. Specific strategies were also employed. For example, South Korea made the use of technology to actively test and trace all cases and contacts. China, used force and regulations to implement a stay-at-home strategy, which ended up being very effective.

Out of the 5 countries under study, South Korea seems to have performed effectively. A very obvious reason was that they could deploy technologically-advanced systems efficiently, and track the virus' path precisely.

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PART 2 – Online Course Report

Name of the course	**Biostatistics in Public Health Specialization** By Dr. John McGready, PhD, MS Associate Scientist, Biostatistics Bloomberg School of Public Health Johns Hopkins University
Corse Description	This comprehensive concept-centric course starts from the basics of biostatistics and goes up to the complex problems with involvement of multiple variables. It helps gain insight into how to read and interpret scientific literature in the fields of Public Health, Biology, Medicine and other related fields. There are 4 courses in this specialization:
	☑ **Summary Statistics in Public Health** Statistical measurement methods within the world of public health research. Practice interpreting data and performing calculations on real data from published studies. Topics include summary measures, visual displays, continuous data, sample size, the normal distribution, binary data, the element of time, and the Kaplan-Meir curve.
	☑ **Hypothesis testing in Public Health** Evaluate sample variability and apply statistical hypothesis testing methods. Perform calculations and interpret real-world data from the published scientific literature. Sample statistics, the central limit theorem, confidence intervals, hypothesis testing, and p values.
	☒ **Simple Regression Analysis in Public Health** Simple regression applied to find out the relationship between outcome and variable.

	☒ **Multiple Regression Analysis in Public Health**	
Objectives	• To be able to read, understand and significantly interpret data from published research projects • To use the knowledge of biostatistics in handling of data • To understand logically the appropriate application of statistical methods according to the research question	
Contents (Courses with certificate)	**Course 1: Summary Statistics in Public Health**	**Course 2: Hypothesis Testing in Public Health**
	Week 1 • The Role of Statistics in Public Health Research • Continuous Data Measures	Week 1 • Sampling Distributions and Standard Errors
	Week 2 • The Normal Distribution	Week 2 • Confidence Intervals for Single Population Parameters
	Week 3 • Binary Data	Week 3 • Two-Group Hypothesis Testing: The General Concept and Comparing Means
	Week 4 • Dealing with the Element of Time	Week 4 • Hypothesis Testing (Comparing Proportions and Incidence Rates Between Two Populations) & Extended Hypothesis Testing • Extending Hypothesis Testing for Comparing More than Two Groups in One Test
Contents (Courses without certificate)	**Course 3: Simple Regression Analysis in Public Health**	**Course 4: Multiple Regression Analysis in Public Health**
	Week 1 • Simple Regression Methods	Week 1 • An Overview of Multiple Regression for

		Estimation, Adjustment, and Basic Prediction, and Multiple Linear Regression
	Week 2 • Simple Cox Proportional Hazards Regression	Week 2 • Multiple Logistic Regression
	Week 3 • Confounding, Adjustment, and Effect Modification	Week 3 • Multiple Cox Regression
	Week 4 • Course Project	Week 4 • Course Project
Learning methodology	The course was completely done online through video lectures, discussion forums and reading material. In addition, there were compulsory timed practice quizzes after completing every week of the module and one timed quiz after the completion of every module. All the parts of this course were done online.	
Key learnings	☑ Calculation of Summary Statistics from Public Health data ☑ Interpretation of graphical as well as written statistical data ☑ Usage of various regression methods and their evaluation and interpretation ☑ Choosing the appropriate statistical method for a given research question	
Application	During the course of the first part of my summer project (the work from home report) I completed a research project which entailed the study of various research papers to get relevant information. The learnings from this online course helped me throughout this project.	