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COVID-19 Risk Analysis in South Asia with Respect to Europe and North America

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***Abstract*— Coronavirus Disease 2019 (COVID-19) was identified in late 2019 and the world health Organization (WHO) declared it as a pandemic on March 11, 2019. World top researchers, physicians, and pharmacists are trying to find out remedy but it is still in the research phase. COVID-19 spread through the air by coughing or sneezing also depends on the environment. In this paper, our main goal is to COVID-19 threat analysis in South Asian people based on their habits, culture, consciousness, etc. compare to Europe and North American culture. The research work is formulated in three steps. Firstly, we formulate a dynamic infection transmission model by considering the fertility rate, mortality rate, transmission rate, and cure rate of the COVID-19 caused death rate as variables. Secondly, we define the variables of the model based on the census of south Asia. Finally, we propose some risk reduction, infection prevention, and control in South Asian countries.**

***Index Terms*— COVID-19, Dynamic Transmission Model, Ordinary Differential Equation, Machine Learning, Risk Analysis.**

I. Introduction

In 2012, the Middle East suffered from a new Coronavirus that caused illness similar to SARS, which is entitled Middle East Respiratory Syndrome Coronavirus (MERS-CoV). Researchers across the globe conducted investigations to understand MERS-CoV and its prevention. While the MERS-CoV is still converging on the world, another extremely pathogenic Coronavirus emerged in Wuhan, Hubei province, China [1-3], currently defined 2019-Novel Coronavirus (COVID-19) [4-6]. On December 31, Wuhan Municipal Health Commission issued an alert about this disease, and the Chinese Center for Disease Control and Prevention (China CDC) sent a rapid response team to Wuhan and sent notification to World Health Organization (WHO) [8,9,16,17, 18]. The transmission process of COVID-19 is similar to SARS-CoV and MERS-CoV and has also been reported [2,7,10] to be transmitted among wild animals in Wuhan's Huanan Seafood Wholesale Market. However, the animal sources of COVID-19 have not been confirmed. Early in the COVID-19 outbreak, it has been confirmed that COVID-19 can transmit from human to human [4, 11].

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The cause of COVID-19 is the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), known as a novel Coronavirus [19,20] and previously titled 2019-nCoV. SARS-CoV-2[21,22] is a positive-sense single-stranded RNA virus. The reported incubation phase is typically between 2-14 days [14,15]. Bats are likely to be the originator of SARS-CoV-2 [12,13], due to the strong genetic similarity of bat Coronavirus. Although, a Pangolin is also thought to be involved as an intermediate reservoir.

TABLE I
PRESENT CONDITION OF COVID-19 IN EUROPE, NORTH AMERICA AND ASIA

Country	Europe	North America	**Asia**
Total Population	747,636,026	368,869,647	**4,641,054,775**
Total Case	55,473,542	48,389,275	**70,406,476**
Total Death	1,175,022	999,356	**1,039,876**
Total Recovered	50,615,851	37,881,343	**65,664,893**
Active Cases	3,682,669	9,508,576	**3,701,707**

Table I shows the present condition of the outbreak of COVID-19 in Europe, North America, and Asia till September 02, 2021[10]. In south Asian country like India, Pakistan and Bangladesh have a high risk of COVID-19 outbreak, due to low medical support, and high population density. Assembling an infection transmission model can help the population and the government to be able to perform risk assessment along with near-future threat analysis of COVID-19.

To estimate and understand the spread of disease among humans, mathematical transmission modeling of diseases has been widely used [27, 28, 29]. Transmission models are essential to measuring the treat a disease can cause and are helpful to limit near future destruction caused by diseases. The COVID-19 virus can infect a COVID-19 recovered person. Transmission models in which a cured individual may again be infected with a disease are often represented as Susceptible-Infectious-Susceptible (SIS) model. These types of models contain two states, susceptible and infectious, where susceptible defines the state in which an individual can be affected by the disease, and infectious defines the state in which an individual is infected with the disease and can spread the disease to others. COVID-19 is very dangerous because of its transmission characteristics. More than 220 million people are already infected by COVID-19 and more than 4 million people died worldwide. Overall, our main contributions include:

1. Develop a dynamic transmission model for COVID-19 for a particular population.
2. Analyze the risk due to COVID-19 for South-Asian country in compare with Europe and North America.
3. Finally, we have proposed risk minimization procedures for COVID-19 in South Asian countries

The rest of this paper is organized as follows: Section II illustrates the characteristics of COVID-19. Section III provides the overall contributions of the proposed model and Section IV contains conclusions.

II. Characteristics of COVID-19

A. Transmission

Generally, People can infect COVID-19 from others who have already been affected by this virus. When a patient with COVID-19 coughs or exhales, tiny droplets from the nose or mouth or other physical contacts might transfer the virus from one victim to another. These droplets are landed on surfaces and objects near the affected person. Other people infect COVID-19 by touching these surfaces or objects, then touching their eyes, nose, or mouth. People can also be infected by COVID-19 if they breathe the droplets from a person with COVID-19 who coughs out or exhales droplets. This is why it is most important to keep a distance more than 1 meter (3 feet) away from a person who is sick.

The fundamental way of virus disease communications is through respiratory droplets expelled by someone during coughing. The risk of infecting COVID-19 from infected persons with no symptoms at all is very low. However, around the world many people with COVID-19 experience very mild symptoms of it. This is partially correct at the early stages of the COVID-19 disease. That's why it is possible to catch COVID-19 from someone who has, for example, just a mild cough and cold, the person does not feel ill. In another approach, the chance of contracting COVID-19 from an infected person's feces appears to be minimal. While preliminary examinations show the disease may be found in feces in most situations, the epidemic does not appear to be propagated primarily through this method. To avoid the risk of infecting from COVID-19 is to clean hands regularly, after using the bathroom and before eating.

Temperature is another main reason for COVID-19 transmission. Jingyuan et. al [23] shows the relationship between weather and COVID-19 where high temperature and high humidity countries (e.g., Singapore, Malaysia, and Thailand) have lower cases per day rather than lower air temperature countries (e.g., Korea, Japan, and Iran). According to Jingyuan et al. [23], the arrival of summer and rainy seasons can significantly reduce the transmission of COVID-19. German virologist Thomas Pietschmann [24], Indian infectious disease specialist Dr. Abdul Ghafur [25] and Dr. Stefan Baral, an epidemiology expert at Johns Hopkins University [26] mentioned natural decrease of Coronavirus transmission. They said Coronavirus is "not very heat-resistant", does not like "Sunlight, Temperature, and Humidity", or "Sunlight is good at killing viruses". According to WHO's report [34], COVID-19 transmission is characterized as sporadic cases, the cluster of cases, community transmission. Sporadic case means the small number of cases detected locally where a cluster of cases refers to cases that detected cluster in time or geographical location or by common discovery and community transmission refers to larger outbreaks of local transmission that detected a specific group of people or multiple clusters in several areas.

TABLE II
Several Symptoms varies in Europe, America& Asia [35-39]

Symptom	COVID-19 Symptoms		Common Cold
	Europe& America	Asia	
Fever	Yes	Yes (may be high grade)	Sometimes usually < 38.5°C
Cough	Yes	Yes (sometimes dry cough)	Sometimes
Runny/Stuffy nose	Sometimes	Sometimes	Yes
Sneezing	Sometimes	Sometimes	Yes
Headache	Yes	Yes (Strong)	Sometimes
Anosmia (loss of smell)	No	Yes	Sometimes
Skin rash	No	No	No
Fatigue	Yes	Yes	Sometimes
Difficulty breathing	Yes	Yes	No
Muscle Pain	Yes	Yes	No

B. Symptoms

Around the world, it is found that the most common symptoms of COVID-19 are fever, dry cough, and tiredness. Aches and pains, nasal congestion, runny nose, sore throat, and diarrhea are all possible symptoms. These signs and symptoms are generally minor and appear over time. It has been discovered that some persons acquire infected yet do not show any symptoms or feel ill. Most people (about 80%) recover from the disease without admitting to the hospital or without needing special treatment. Some people (around 15%) become seriously ill due to COVID-19 and develops difficulty breathing. People over the age of 65, as well as those with underlying medical issues such as high blood pressure, heart disease, or diabetes, are more prone to acquire severe diseases. About 2% of those who have contracted this new illness have perished. People who have a fever, cough, or trouble breathing should visit a doctor. Table II shows several Coronavirus symptoms some appear in Europe and America and some appear in the Asia region. Also shows some symptoms for normal cold which are not COVID-19 symptom. If someone exhibits physical problems such as difficulty breathing, chest discomfort or pressure, new disorientation, inability to wake or stay awake, or blue lips or face indications, get emergency medical attention right away.

C. Diagnosis

The World Health Organization has announced some testing guidelines and protocols for testing Covid-19. For Covid-19 testing WHO suggested using the real-time reverse transcription-polymerase chain reaction (RRT-PCR) process. Generally, this test requires several hours to obtain the test results. The test can be performed on blood or respiratory samples. However, according to Chinese pulmonologist Wang Chen, this type of RT-PCR testing results in 50-70 percent of false positives. Chinese scientists were able to isolate a strain of the Coronavirus and publish the genetic sequence, allowing laboratories all around the globe to create their PCR assays to identify virus infection.

D. Management

In this crisis moment of earth, there are few antiviral medicines to prevent COVID-19. Moreover, those who are affected by this virus should receive care to relieve their symptoms. It is generally suggested that people with serious illnesses should be hospitalized and those who are mild conditions should be isolated. Most of the patients are recovered by supportive care. There is a light of hope that dozens of companies declared about their success of possible vaccines and medicines. Clinical studies are being conducted on them. The World Health Organization (WHO) is coordinating efforts to produce COVID-19 vaccines and medications to control and cure the disease.

III. Proposed Method

The research work is carried out in three steps. First, we define the transmission model from the perspective of COVID-19. Second, we define the constant variables used in the transmission model, considering the available population data of Bangladesh. Finally, we analyze the threat caused by COVID-19, considering different scenarios and precautions performed by the population.

A. Dynamic Transmission Model of COVID-19

The model describes the dynamics of COVID-19 transmission on a particular population. In this transmission model, we consider one area that holds a total population of N, including two disease statuses, S, and I (where N= S + I). The subset of the population who are susceptible to the virus is declared as S whereas, the subset of the population who are infected by the virus is declared as I. Someone who is cured of the virus (was on population subset I) is moved to the susceptible state. The infected individuals of the population subset I have a recovery rate of γ. The population of infectious individuals is increased by infection of susceptible with a transmission rate of β. We also consider the birth rate of the total population, which is denoted as μ. The natural death rate of the susceptible individuals is denoted as ν whereas the COVID-19 provoked death rate of the infectious is denoted as η. Fig .1 illustrates the models along with the parameters. With the stated assumptions and the illustrated model in Fig. 1, we derive a two-dimensional system of the nonlinear differential equation for the COVID-19 transmission,

$$\frac{dS}{dt} = \mu N - \frac{\beta SI}{N} + \gamma I - \nu S \quad (1)$$

$$\frac{dI}{dt} = \frac{\beta SI}{N} - \gamma I - \eta I \quad (2)$$

The transmission rate β controls the rate at which disease spread. β has a direct relation to two parameters, p, and C stated as $\beta = pC$. p defines the probability of an individual being infected by the disease, and C represents the contact rate of individuals.

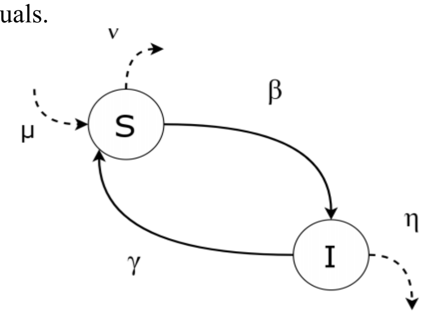

Fig. 1. The SIS transmission diagram of COVID-19 model.

Also, the individual contact rate C has a direct relation with the density of a population, which we define by ρ, and a constant factor c_0. c_0 defines the per-link contact rate, and the value of the constant decreases if the probability of contact between people of an environment starts to decrease. This type of density-dependent transmission is named 'pseudo' mass action [30]. Therefore, $C = \rho c_0$, and $\beta = pC = p\rho c_0$. Also, if we represent A as the area of the environment, the overall population N can be represented as $N = \rho A$. Considering the value of β and N we can rewrite equations 1 and 2 as:

$$\frac{dS}{dt} = \mu \rho A - \frac{pc_0 SI}{A} + \gamma I - \nu S \quad (3)$$

$$\frac{dI}{dt} = \frac{pc_0 SI}{A} - \gamma I - \eta I \quad (4)$$

All the parameters used in the model are the positive and variable domain of the model, denoted as Ω is estimated as:

$$\Omega = \{(I, S)\epsilon\mathbb{R}^2 : I, S \geq 0\} \quad (5)$$

Table III contains a short description of the parameters.

TABLE III
THE PARAMETERS USED IN THE SIS

Description	Parameter	Value
Birth rate of the overall population	μ	22.5
Natural death rate of susceptible population subset	ν	5.9
COVID-19 death rate of infectious population subset	η	0.01
Transmission rate of COVID-19	β	0.04
Recovery rate from COVID-19	γ	0.045
Probability of being infected	p	-
Population density	ρ	964.42
Per-link contact rate	c_0	-
Area of the environment	A	-

1) Parameter Initialization

To calculate the parameters of the model, we use the population census 2011 of Bangladesh [31]. Using the census data, we define the parameter values as follows:

- The overall population of Bangladesh is 142,319,000, so N = 142,319,000.
- The crude birth rate (per 1 year, per 1000) of the population is 22.5, therefore,
  $$\mu = \frac{22.5}{365 \times 1000}$$
- The crude death rate (per 1 year, per 1000) of the population is 5.9, therefore,
  $$\nu = \frac{5.9}{365 \times 1000}$$
- The land area of Bangladesh is 147,570 km^2, therefore, the population density, $\rho = \frac{142,319,000}{147,570}$, and area, A = 147,570.

To estimate the COVID-19 death rate and recovery rate, we investigated the followings:

- We investigated that each infectious person dies after 19 days [32]. By the World Health Organization situation report-52 (March 09, 2021) [33], globally 125,048 COVID-19 cases were confirmed with 4,613 death cases. By considering this information we can calculate the death rate caused by COVID-19, $\eta = \frac{4,613}{19 \times 125,048}$.
- We studied that each infectious person requires 22 days to be cured [32]. Therefore, the recovery rate, $\lambda = \frac{1}{22}$.

B. Threat Analysis

COVID-19 is a human-to-human transmittable disease that transmits through small droplets from the nose or mouth. The virus can be transmitted by the droplets directly or indirectly. It is reported that the virus can survive 12 hours on a surface and can spread 1 meter from an infectious individual.

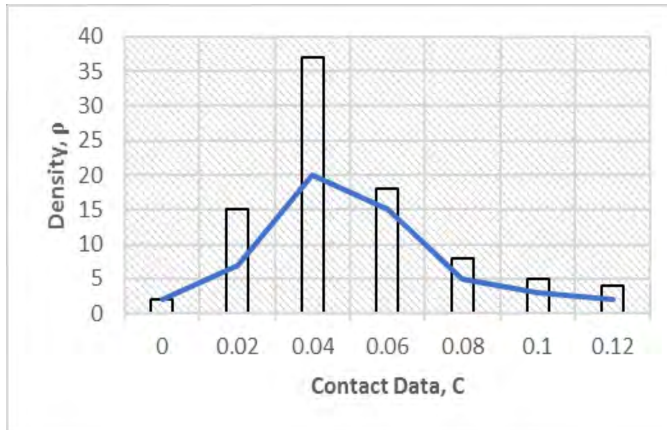

Fig. 2. The distribution curve of the transmission rate, β.(legends)

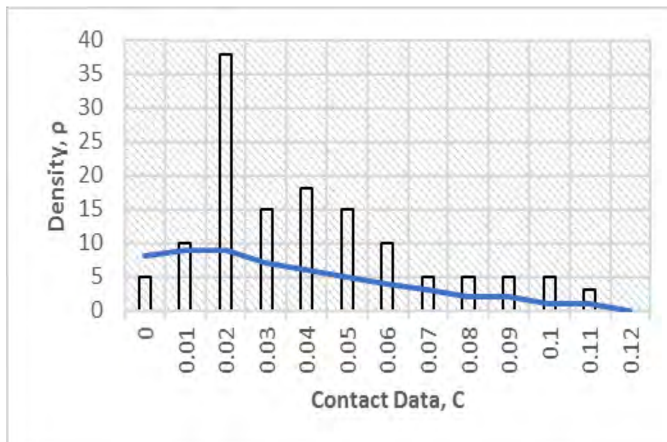

Fig. 3. The distribution curve of the death rate, η.

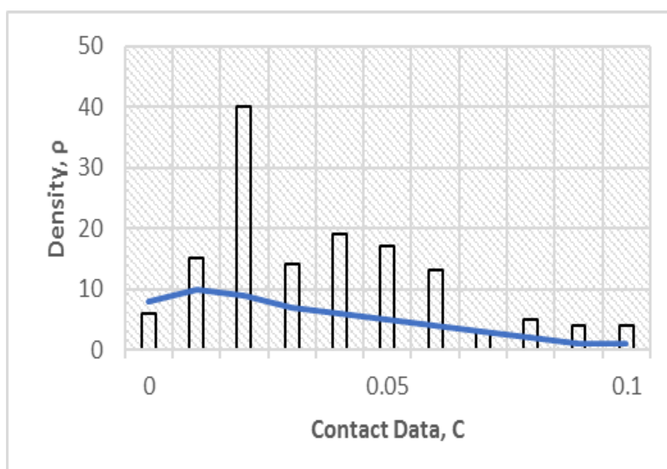

Fig. 4. The distribution curve of the recovery rate, γ.

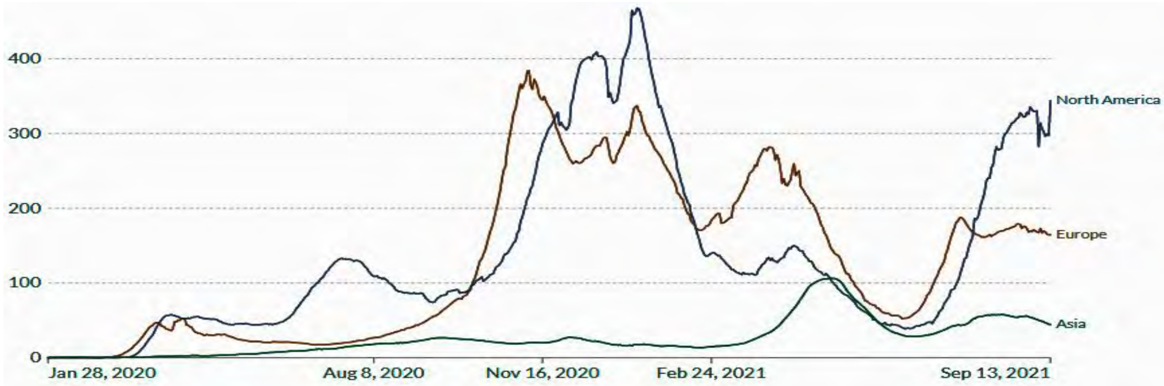

Fig. 5. The daily new confirmed COVID-19 infected people (per million) in South Asia with respect to Europe and North America [34] (Updated September 15, 2021).

The epidemic began in Bangladesh, with 3 people afflicted. The number of persons who were originally affected is believed to be ten based on the stated number of people who came into touch with the first sick patients. Fig. 2-4 shows the posterior distribution of the system model. Instead of fixed values, the theory suggests infection spread using time-dependent attributes of such factors. The stated and model were used to calculate all of the parameters. For a given period, the recovery rate is lower than in other nations. For example, China and Italy had success rates of 0.035 and 0.023, respectively. The fewer recovery ratio represents the country's healthcare infrastructure.

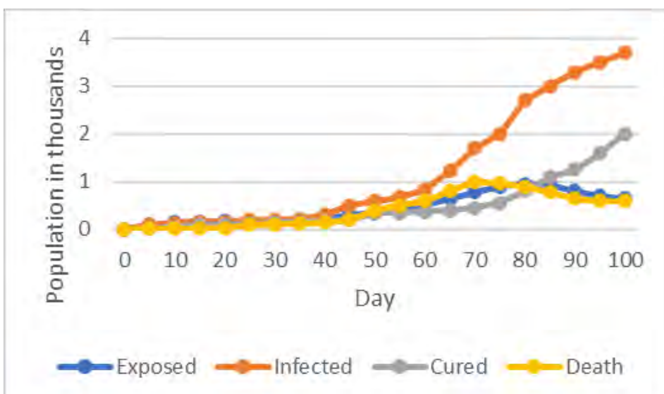

Fig. 6. Prediction curve of the proposed model.

WHO executive director Michael Ryan said that people did not know the behavior of COVID-19 virus in different climate conditions. But there found a relation between climate condition and the COVID-19 virus after analyzing different countries and the number of cases affected per day in those countries. Fig. 3 shows the daily new confirmed cases in different regions. Since the beginning of 2021, there has been an increase in daily confirmed cases in Asian countries, which is very worrying for Asians. In the summer season, the average temperature in Asian countries is above 28°C, so the incidence of daily infections was lower than in Europe and North America before September 2, 2021, as shown in Fig. 5.

We simulated the transmission possibilities until 100 days after May 08, 2021, using the expected values of the parameters β, γ, and η. Fig. 6 shows the outcomes of the simulations based on the presented data. The simulation was done with the SIS model, and the outbreak predicted scenario is marked by a high level of uncertainty. In specifically, simulations predict some active affected individuals of almost 37,500. Similarly, the simulation predicts a population of 20,500 for the restored population, with lower and upper limits of 9,200 and 42,000, respectively. Finally, simulations show that 3,350 people die on average, with lower and higher limits of 1,500 and 7,400, respectively. Fig. 6 shows the results of fitting the (numerical) solution of Equation 3.

The proposed model is implemented using Anaconda, Scikit-learn, Seaborn, and Panda's machine learning tools. All the analysis graphs were automatically generated using the Matplotlib python library. The model's parameters were estimated using real data [34] from several regions from January 20 to September 1, 2021. Seventy percent (70%) of dataset is used for training purpose and rest of thirty percent (30%) dataset is used for testing purpose. Following that, the actual data collected between March 16 and September 2, 2021, as represented by the blue and red solid lines in Figs. 7 and 8, was used as the test data for the proposed model's validation. Using the estimated factors given above, we projected the total number of confirmed patients and confirmed fatalities and achieved the following findings, as shown in Fig. 7 and 8. Fig. 8 depicts the total number of confirmed cases throughout time. As illustrated in Fig 8, the projected values of confirmed cases for the Asia continent are represented by the black dashed line, whereas the actual instances are represented by the blue solid line. The anticipated values of deaths for the Asia continent are shown by the black dashed line, whereas the actual instances are represented by the red solid line in Fig. 8. The accuracy of the proposed model is 85% in case of confirmation and 75% in case of death.

Fig. 7. Cross-validation (verification) of cases prediction curve with respect to the actual data in Asia.

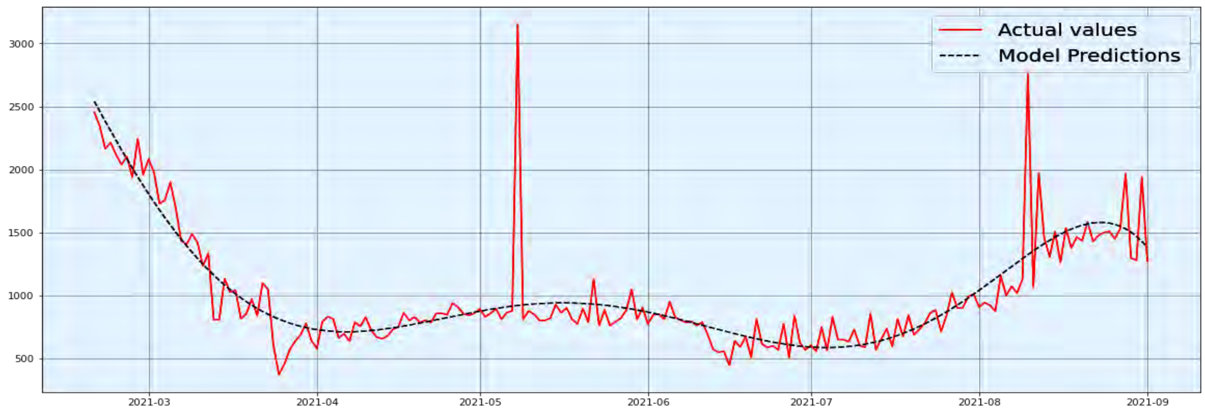

Fig. 8. Cross-validation (verification) of death prediction curve with respect to the actual data in Asia.

C. *Proposal for risk minimization in South Asia*

In America and Europe, most of the people are conscious and educated but still, now America has high infected and dead people than other countries. It is a great concern if Asian people did not aware of this, they have to give high lives than America and Europe. World Health Organization (WHO) gives some suggestions to protect ourselves from COVID-19 shown in Fig. 9 where social distance is very important, if we maintain social distance from others then we can minimize our risk.

Fig. 9. How to protect yourself?

TABLE V
DIFFERENT RATE BY REGION

Region	Affected Rate	Death Rate	Recovered Rate	Active Case Rate
Europe	7.42%	2.12%	91.24%	6.64%
North America	13.12%	2.07%	78.28%	19.65%
Asia	**1.52%**	**1.48%**	**93.27%**	**5.26%**

For people's awareness if we set different types of awareness related to COVID-19 billboards in important places then people will be conscious and they can protect themselves by maintaining home quarantine if they found any symptoms. WHO published a report shown in Fig. 10, where shows most common symptoms are fever, fatigue, and dry cough. Eighty percentages (80%) of patients show this common symptom and some patients have other symptoms which are not common to others as the COVID-19 changed their genome from place to place. If any patient found these symptoms, then we must keep him in quarantine and maintain social distance in order to risk minimization. The COVID-19 death rate is increasing day by day, up to 1st September 2021 total confirmed death for COVID-19 is 4,545,523 wherein Europe has 1,75,002 confirmed deaths, 999,365 in North America and 1,039,876 confirmed deaths in Asia region as shown in Fig. 10. Asia has till bottom level and lower number of deaths than

Fig. 10. Total Confirmed COVID-19 Death (per million people) in South Asia with respect to Europe and North America [34] (Updated September 01, 2021).

Europe and North America. Table V shows death rate in different regions and in Europe has highest death rate and Oceania has lowest death rate. In Asia, there have highest number of population than other region, so it is emergency to take necessary steps such as location tracking, contact tracing, banning foreign visitors, prohibiting mass gathering, restricting religious-related activities, etc. to protect peoples from COVID-19 and control death rate.

TABLE VI
VARIANTS OF CONCERN FOR ASIAN COUNTRIES [34]

Parameters	Alpha	Beta	Gamma	Delta
First Detected Country	United Kingdom	South Africa	Brazil	India
First Detected Year and Month	September 2020	September 2020	December 2020	December 2020
Transmissibility Impact	Yes [47]	Yes [52]	Yes [56]	Yes [58]
Immunity Impact	Yes [50, 51]	Yes [53, 54]	Yes [57]	Yes [59-61]
Severity Impact	Yes [48, 49]	Yes [48]	Yes [49, 55]	Yes [60, 62]
Transmission Classification	Community	Community	Community	Dominant

High temperature, humidity, and sunlight are very important to reduce Coronavirus transmission from one community to another community [23-28]. Asian countries like India, Bangladesh, Malaysia, etc. have high temperatures and humidity which could be one of the reasons that Coronavirus is not spreading faster. If Coronavirus transmission depends on temperature effect, then Asian infected people will be a lower number than Europe and North America.

Table VI shows different variants of concern for COVID-19 for Asian countries and their impacts where most of the transmission is a community of case transmission. Social distance maintaining, Self-quarantine, and other COVID-19 prevention steps can protect community transmission and daily affected cases.

D. COVID-19 Infection prevention and control

In America and Europe, most of the people are conscious and educated but still, now America has high infected and dead people than others country. There are some suggestions for COVID-19 infection prevention and control.

1) Infection prevention and control during health care when COVID-19 is suspected [42]
2) Infection Prevention and Control guidance for Long-Term Care Facilities [43]
3) Infection prevention and control for the safe management of a dead body in the context of COVID-19[44]
4) Considerations for quarantine of individuals in the context of containment for coronavirus disease (COVID-19) [45]
5) Advice on the use of masks in the context of COVID-19 [46]
6) COVID-19 vaccine advice [63]

Fig. 11. Received at least one dose of COVID-19 vaccine in Europe, North America and Asia (Updated August 31, 2021).

TABLE VII
DIFFERENT COVID-19 VACCINES

Name	Age limit	No. of shots	Vaccinated time
Pfizer-BioNTech	12	2	2 weeks after second shots
Moderna	18	2	2 weeks after second shots
Johnson & Johnson's Janssen	18	1	2 weeks after the shot

People have been vaccinated since December 2, 2020, as shown in Figure 11. Table VII shows different types of recognized COVID-19 vaccines. Johnson & Johnson has only one shot of the Janssen vaccine and all vaccines will be fully effective two weeks after the last shot.

IV. CONCLUSION

In this paper, we have analyzed the COVID-19 risk in the south Asia region by building a model and suggest some ways to minimize the Coronavirus risk of Asian people because most of the people in the South Asia region are not conscious about this disease compared to American and European people. Using a modeling technique, we were able to quantify the present transmission conditions in Bangladesh. The number of persons affected during the COVID-19 virus epidemic in Bangladesh is a good indicator of the virus's spread. We have analyzed the affected rate between Europe, North America, and Asia where Asia has the lowest affected rate so far compared to other regions. Then we have proposed some methods to reduce the risk in Asia. The suggested method might be used to track infection transmission rates and forecast illness supporting documents in the future. This study may be included in the decision-making process for disease prohibition and control by healthcare practitioners.

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