Erection of Spatial- Network Disease Models for Novel COVID- 2019 with Lockdown/ Quarantine and Effects of Social Distancing

Muhammad Ilyas[*], Shaheen Abbas[**], Afzal Ali[**], Syed Akhtar Raza[**], Wajid Ali[***]

[*] Department of Mathematics, Government College University Hyderabad, Sindh, Pakistan

[**] Laboratory for Applied Mathematics and Data Analysis (LAMDA) Mathematical Sciences Research Centre, Federal Urdu University of Arts, Sciences and Technology, Karachi, Pakistan

[***]Department of Computer Science Federal Urdu University of Arts, Sciences and Technology, Karachi, Pakistan

[****]Department of Mathematical Sciences Karakoram International University Gilgit. Pakistan

Abstract- The present study is assessed a Susceptible-Exposed-Infectious-Recovered (SEIR) disease on network structure by spatial model erection. These network models are articulated to deliver the pandemic and elimination of the (2019-nCoV/SARS-CoV-2). The dynamics of the epidemic novel disease COVID-19 in the country of Pakistan is revealed using the spatial SIR-SEIR models in the activated extent (from 26 February to 31 July 2020).These models are described the pandemic transverse the domain depending on some obliteration and control measures. The quarantine/lockdown is merged into the SIR-SEIR models. The infectious and recovery tracing parameters (β, λ , α and γ) are main parameters of the epidemic, for which the proportion of the decisive number of infections to the peak infections proportion can be found methodically a perpetual decrease in the contact rate in contrast, social distancing consents to complete and not revive the pandemic when the distance is reduced, to the extent that the number of infectious uninterrupted in the limit that $\gamma \rightarrow \infty$, an epidemic has been declined, although some virus persist except in isolated public areas, and the epidemic rejoinder when social distances shrink, the pandemic is started again, All over world is adopted social distancing as an anticipation dimension to reduce spread. The effect of social distancing showed that with in social distancing can spread rapidly from polynomial to Linear (R^2 = 0.91), breakage of social distancing disease pandemic rises 4^{th} degree polynomial (R^2 = 0.812). Our results are detected that the proposed model parameters are more accurate in estimating the spread of disease.

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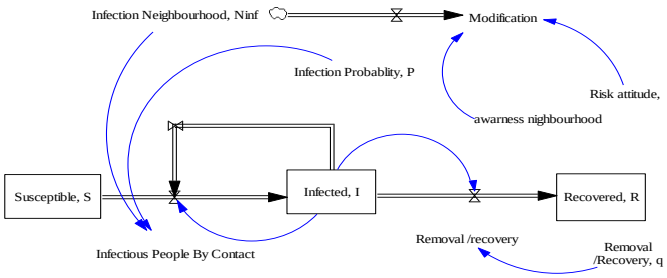
Index Terms- Corona Virus (COVID-19), Quarantine, Lockdown, Social Distancing, Spatial Network, Susceptible-Exposed-Infectious-Recovered (SEIR).

I. INTRODUCTION

The structure of real-life networks is distant from stable and frequently responds to epidemics that spread to individual and at population level [1]. The regular network that has the advantage of simplicity but is an erratic interpretation of real social network, consequently, we are considered a network Susceptible, Infectious, Exposed and Recovered/ Removal (SIR-SEIR) spatial erection that is essential on the spatial network lockdown/ quarantine with respect to without and with social-distancing (people to people contacts proportion). The spatial network basic Susceptible Infectious Recover/Removal (SIR) models by neighbourhoods discussed in Euclidean distance, every individual has an infection neighbourhood which size, and the number of contacts thru in the individual, which is differs in the vicinity on the infection pressure, then changes throughout the epidemic [2]. Supposing that individuals have been situated at the square lattice nodes, which is signifying their geographical distribution [1]. Every node of the lattice is griped a single individual, whichever susceptible, infected or removed /recovered. We also studied a neighbourhood of the centered radius r at a node is (i_0, j_0 , computed by Euclidean distance, the two types of neighbourhoods topologies are expressed that the infection neighbourhood radius r_i is described spread of the infection ,although the alertness neighbourhood is defined the individual influence obtained by radius r_a .The both radii has range from $0 \rightarrow \infty$, it intended there is zero that n_0 neighbours and infinity is total population, the individuals in all neighbours is proportional to the radius square is r^2,Ni is the number of nodes in all infection neighbourhood an N_a is the number of nodes in each awareness neighbourhood, all individuals are allocated the same criterion infection neighborhood in radius $r_i^{(0)}$ and $N_i^{(0)}$ is the individuals numbers in each infection neighbourhood [3].

The entirely individuals are initially subscribed Susceptible (S) people and the disease epidemic detected number of few infected people (I) at any random location in the network [3, 4]. The individual susceptible people are affected with individuals' infectious people in an infected neighbourhood in a specific time t.so, each of contact among the susceptible and infected individual become infected with probability p per contact, each individual infected can become recovered, with the probability q with respect to particular time interval. The Spatial network disease structure

(Susceptible-Infected-Recovered) model is represented in flowchart diagram 1.



Flowchart Diagram 1. Spatial Networking Disease structure with Susceptible, Infected and Recovered

We have distinguished a disease structure for spatial network in the three categories of total population P of fixed size N, those individuals in particular time duration *t* who have not yet contracted the disease (S_t), those removed who can no longer contract the disease, those recovered and removed/(dead) and remain infected in time [5], Accordingly,

$$\begin{aligned} P &= S_t + I_t + R_t \\ S_t &= T_P - (I_t + R_t + D_t) \end{aligned} \quad (1)$$

The susceptible-infectious-recovered and death/removal are typically put into a set of modern equations by Spatial Network disease SIR-SEIR models in § 2.

II. Data Description

The daily pandemic data of Corona (2019-nCoV/SARS-CoV-2 from 26 February 2020 to 31 July 2020 are collected from the https://www.who.int and https://covid.gov.pk, WHO, The Ministry of National Health Services, Regulations and Coordination Field Epidemiology and Disease Surveillance Division(FEDSD), National Institute of Health(NIH), Islamabad website. We have divided data sets in three segments 26 February to 26 May 2020 (included lockdown/quarantine periods) and 27 May 2020 to 30 June 2020(included relaxation period of lockdown and smart/ sensitive areas lockdown) and 1 July to 31 July 2020(follow by social distancing and SOP awareness not all utmost of people). The disease of Novel-COVID-19 in all provinces of Pakistan including Sindh, Punjab, Baluchistan, KPK, Gilgit Baltistan (G.B) and Azad Jumu Kashmir (AJK) and Capital of Pakistan Islamabad are considered by exhausting SIR-SEIR networking disease models with lockdown/quarantine and effect of social distancing. The Vensim software and excel 2019 are used to manipulated and analysis with graphical presentation of time series data base, respectively.

2.1. The Spatial Network SIR - SEIR Disease Models

The Spatial Network SIR model is based on three main booths for the epidemic disease. We are supposed that there is current situation of novel (2019-nCoV/SARS-CoV-2) coronavirus disease has Susceptible (S), Infected (I) and Recover/Removed (R) classes. The initial stage is considered as a susceptible class of people, who has not COVID-19 disease. The infected class is contained individuals who are infected, while individuals who are recover or die from the COVID-19 transfer to the removed class. Whenever a susceptible people are contact with the infectious people, the probability of infected people may be increase. The model equations inferred from causes tree diagram 2.

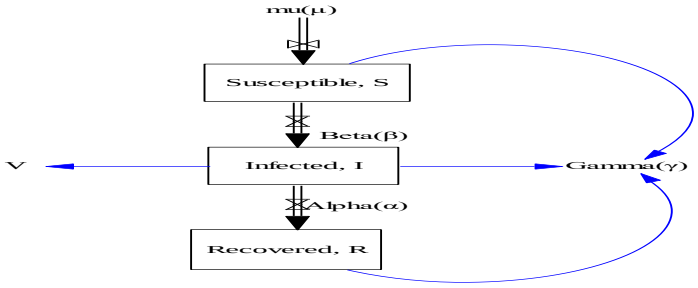


Diagram 2. Causes tree diagram for SIR Model with parameters

The SIR model is designed with parameters, the parameter β is called the rate of infection, the parameter α is denoted the rate of discharge into removed class.by the demographic statistics birth and natural death rate is shown by μ and γ respectively [6, 7]. The SIR model excluded the natural deaths from the COVID-19 death result, respectively. The Causes tree SIR diagram (depict in 2) is helpful to explain the conceptualization with model equations,

$$\begin{aligned} S_0(t) &= \mu N - \beta SI - \gamma s \\ I_0(t) &= \beta SI - (\gamma + \alpha_1) I \\ R_0(t) &= \alpha_1 I - \gamma R \end{aligned} \quad (2)$$

In equation 1, the total population size N is $S_0(t)+I_0(t)+R_0(t)$, the number of susceptible people *S* interact parameter β in a day, I/N of them are infected, βSI is indicated a homogeneous mix (bi-linear incidence time interval) of the population of susceptible-infected and the epidemic disease death rate in terms of (model parameter υ. The SIR model infected I (t) equation is modified as:

$$I_0(t) = \beta SI - (\gamma + \alpha_1 + \upsilon) I \quad (2.a)$$

Beside affections of epidemic (coronavirus) disease, the natural death and birth are detected to be negligible in the during of disease pandemic. The solution of the SIR model equations (1). The assumptions of the SIR, Susceptible S to the infected I class is reformed the transition rate βI/N, where the probability of infectious population per total number of population (I/N) that the disease would be transmitted from the infected to a susceptible people individual, the other reduction of SIR model equation (2) is

$$\begin{aligned} \boldsymbol{S'(t)} &= -\beta S \\ \boldsymbol{I'(t)} &= -\beta S \frac{I}{N} - \alpha_1 I \\ \boldsymbol{R'(t)} &= \alpha_1 I \end{aligned} \quad (3)$$

The Spatial -Network SIR disease model is also indicated a time dependent constraint, such as infected to removal/recover class out flow rates are retained changing in deference to time [6, 7]. The rate of infection preceding to lockdowns, closure to international and national travelling and public gathering would be differ after various measures have been executed. Additionally, the rate of recovery might be diverged, when a country/region is not able to

adequate medication and medical services, when the same country or region has enough of such supporting substances. So, these types of conditions will be occurred SIR model equation (3) is modified to integrate the time-depended transmissions with time dependent parameters transmission rate β(t) and recovery rate α(t). The modified equation (3) becomes,

$$\left.\begin{aligned} \boldsymbol{S'(t)} &= -\beta(t)S\,\frac{I}{N} \\ \boldsymbol{I'(t)} &= -\beta(t)S\,\frac{I}{N} - \alpha_1 I \\ \boldsymbol{R'(t)} &= \alpha(t)I \end{aligned}\right\} \quad (4)$$

Also, **t**he SEIR models have five or four booths liable on the classification of infected (I) class. The infected class is categorized more parts such as asymptomatic and symptomatic. [6]. The asymptomatic class are signed that the infected people are not exposed any symptoms of disease such as COVID-19. However, when the infected people are noticeable with symptoms of disease. The SEIR model has Susceptible, Exposed, Infected and Removed are persisted the SIR model equations (2). Nonetheless, the SEIR with four booths parts are shown in causes tree diagram 3.

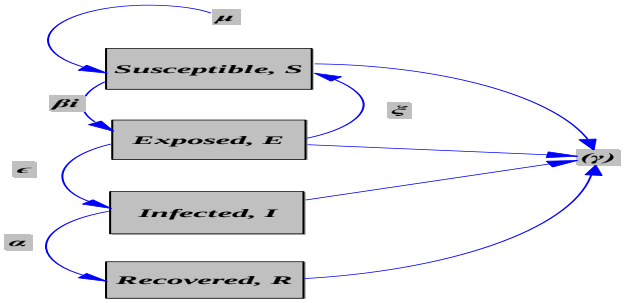


Diagram 3. Causes tree diagram for SEIR Model with parameters

The susceptible people contact to infected persons that transmit virus to become the Exposed (E) class. When, the test result is negative, the exposed people come back to susceptible class. The parameters ξ is indicated the rate of incursion rate into susceptible from exposed class, the parameter β_1 is depletion rate from susceptible to exposed and is depletion from exposed to infected, and α_1 is depletion rate from infected to removed class. The parameters μ and γ is also represented birth and death rates as well. The equations are computed from the figure 3 as

$$\left.\begin{aligned} \boldsymbol{S'(t)} &= \mu N - \beta_1 SI - \gamma S + \xi E \\ E'(t) &= \beta_1 SI - (\gamma + \epsilon + \xi)E \\ \boldsymbol{I'(t)} &= \epsilon E - (\gamma + \alpha_1)I \\ \boldsymbol{R'(t)} &= \alpha_1 I - \gamma R \end{aligned}\right\} \quad (5$$

Even so, the five booths liable of SEIR model is displayed in causes tree diagram 3. The symptomatic and asymptomatic classes are revealed with the I_s(infected people existing symptoms) and I_a (no disease symptoms, still individuals are transmitted) respectively. the other parameters φ and α_3 are play a vital role of oncological diagnostic scrutiny in current active COVID-19 disease pandemic, φ is relevant the rate of depletion from the I_a to Is class and α_3 is denoted the recovery rate of I_a people without indicated symptoms of disease, Similarly, the immune system of people is contesting the disease naively are classified under the asymptomatic class [6, 8].

$$\left.\begin{aligned} \boldsymbol{S'(t)} &= \mu N - \beta_1 S(I_s + rI_a) - \gamma S + \xi E \\ \boldsymbol{E'(t)} &= \beta_1 S(I_s + rI_a) - (\gamma + \epsilon + \xi)E \\ \boldsymbol{I'_s(t)} &= \epsilon k E + \phi I_a - (\gamma + \alpha_4)I_s \\ \boldsymbol{I'_a(t)} &= \epsilon(1-k)E - [\gamma + \alpha_3 + \phi]I_a \\ \boldsymbol{R'(t)} &= \alpha_4 I_s + \alpha_3 I_a - \gamma R \end{aligned}\right\} \quad (6)$$

The SEIR model equations with Is and Ia variables are obtained from diagram 3 (equation 6). The removal rate of asymptomatic People (α_3) and symptomatic people (α_4), when the proportion of exposed people is entered to symptomatic class is shown by κ, while (1 − κ) is the displayed is asymptomatic class, infectious is reduced by the other factor τ respectively [6, 7, 9].

2. Quarantine and Lockdowns intended for COVID-19

The SIR-SEIR models with quarantine and partial or total lockdowns are explored for COVID-19 disease. The S, I, R classes are contained new Q and L class sections, Lockdown class (L) is only covered the susceptible people are controlled their movement to exploring the disease. the people get to the infection, they are moved (lockdown) to be consider susceptible class, when these people are found to perceive disease are ordered as quarantined. The individual people are also on self - quarantine, these isolated peoples are assumed to be quarantine class (Q). Some of infected people are moved into removal class without certainly being quarantined. the SIR-SEIR Causes tree diagrams 4 and 5 are depicted that the performance of the various parameters such as θ_1(infected are quarantined to reduce the spread of disease also receive treatment), θ_2(rate of discharge from E to Q class, E may not be traced to Q move to I class), α_2(removal rate after quarantined class), η and δ (infected move to susceptible and lockdown classes). These parameters are found in equations 7 for SIR quarantine and equation 8 for SEIR quarantine separately.

$$\left.\begin{aligned} \boldsymbol{S'(t)} &= \mu N - \beta SI - \gamma S \\ \boldsymbol{I'(t)} &= \beta SI - [\gamma + \theta_1 + \alpha_1]I \end{aligned}\right\} \quad (7)$$

$$\left.\begin{aligned} \boldsymbol{Q'(t)} &= \theta_1 I - [\gamma + \alpha_1]Q \\ \boldsymbol{R'(t)} &= \alpha_1 I + \alpha_2 Q - \gamma R \end{aligned}\right\} \quad (8)$$

The all classes of SIR-SEIR model with lockdown and quarantine causes tree illustrated in diagram 4-5.

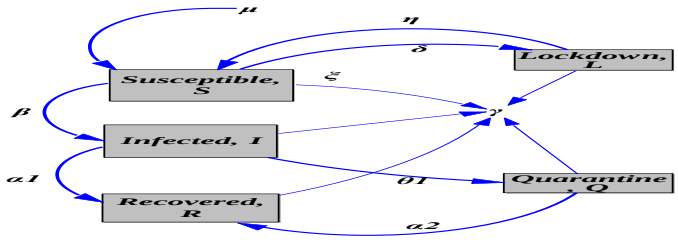


Diagram 4. Causes tree diagram for SIR Model parameters by Quarantine and Lockdown

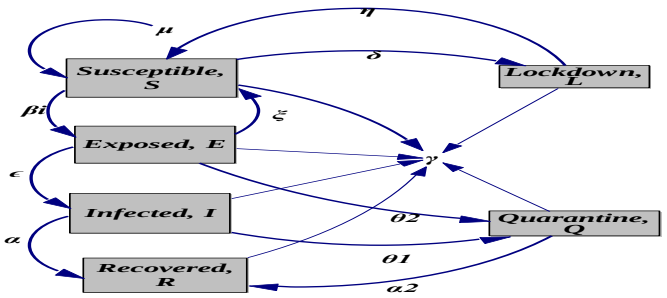


Diagram 5. Causes tree diagram for SEIR Model parameters by Quarantine and Lockdown

It is assumed that the frequency of movement after the susceptible to the infected and then removal or recover class with all parameters are expressed SIR-SEIR equations 9 and 10 with quarantine and lockdowns positions.

$$\begin{aligned} \boldsymbol{S'(t)} &= \mu N - \beta_1 SI - (\gamma + \eta)S + \delta L \\ \boldsymbol{L'(t)} &= \eta S - (\gamma + \delta)L \\ \boldsymbol{I'(t)} &= \beta SI - (\gamma + \theta_1 + \alpha_1)I \end{aligned} \quad (9)$$

$$\begin{aligned} \boldsymbol{Q'(t)} &= \theta_1 I - [\gamma + \alpha_2]Q \\ \boldsymbol{R'(t)} &= \alpha_1 I + \alpha_2 Q - \gamma R \\ \boldsymbol{S'(t)} &= \mu N - \beta_1 SI - (\gamma + \eta)S + \delta L + \xi E \\ \boldsymbol{L'(t)} &= \eta S - (\gamma + \delta)L \\ \boldsymbol{E'(t)} &= \beta SI - [\gamma + \theta_2 + \epsilon + \xi]I \\ \boldsymbol{I'(t)} &= \boldsymbol{\epsilon} E - (\gamma + \theta_1 + \alpha_1)I \\ \boldsymbol{Q'(t)} &= \theta_1 I + \theta_2 E - [\gamma + \alpha_2]Q \\ \boldsymbol{R'(t)} &= \alpha_1 I + \alpha_2 Q - \gamma R \end{aligned} \quad 10$$

In the absence of social distancing, the long-term actions of the network models are depending, that the infection could be transmitted to a susceptible individual from one of its neighbors to another [1, 3]. The total number of contacts in the duration of disease spread is assembled by number of infected(size) and duration of the epidemic. The size is determined how many people are still susceptible and therefore use it (infected and recovering people do).

3. Consequence of SIR-SEIR Models by Infectious-Contact-Social Distancing Tracing

The number of people reduce their contacts in proportion to the probability of infectious people is increased, the growth rate of the parameter β behaviorally, how many people contact in every day, the log function equations for calculate the parameter α_I and α_D for reducing infectious and death/ removal people per day. the logarithm values cannot be negative, the logarithm parameter β value is also uncertainty, this function is performed that super spreading activities is under control at initial declines in the parameter β are relaxed. Infectious reducing parameters and people reducing contact given death rate parameter

For α_I solved: $Log\ (\beta t) = log(\beta_0) - \alpha_I \frac{\Delta I_t}{N_t}$ (11)

For α_D solved: $Log\ (\beta t) = log(\beta_0) - \alpha_D \frac{\Delta D_t}{N_t}$

As, we know that susceptible and infectious people are depended the number of testing, if lack of testing we cannot found the actual number of infected people at any time, So, second function equation are supposed as a substitute people reduce contacts according to the current death rate .The Social distancing to evaluate their impact on infectious disease (COVID-19) pandemic are deliberated in underneath .

The SIR-SEIR networking assumed that the contact rate time varying parameter βt and infected people rate towards to contact rate parameter relationship is βtIt/N, detention of social changes such as social distancing. The parameter of β in related to the reproduction rate R_0 is an infection from one ill people is equal to the number of contacts per day times, the number of days contacts are infectious ($R_0 = \beta/\gamma$). In specific initial expression and exponential growth rate of infections as

$$\begin{aligned} \beta_t &= \beta_0 e - \lambda t + \beta * (1 - e - \lambda t) \\ \beta - \gamma &= \gamma (R_0 - 1) \end{aligned} \quad (12)$$

where, the βt is decline procedure parameter, which is expressed exponentially decays from initial and final contact value parameters β_0 and β∗ at rate of the parameter λ control the speed of occurrence, the average number of days a people is infected Poisson rate is 1/γ . When the parameter βt = β, $I_1 > 0$ and $S_1 > 0$ when the pandemic are activated with non-zero initial values of $I_1 > 0$ and $S_1 > 0$ and without any moderated polices in place it will spready widely, $R_0 > 1$, finally if the R_0 is substantially in terms of unity (by the description of SIR the constant value of β thus constant value R_0, the disease growth is exponentially ,the huge number of population is infected, each number of people become the recover/remover not susceptible people [3, 10, 11].

The disease high spread, when the values of parameter is $R_0 s_0 < 1$ the number of infected people is decline speedily(disease is decay), the total number of new infectious people at a location in time is $\beta_t \frac{I_t}{N} \cdot S_t$,when, the infectious period(time interval) is over, people remain in a resolving state R, a constant parameter fraction θ, of people exit this state , the infected people are resolved in death or recovery state**.** As an alternative, a fluctuating β_0 to β∗ is contacts rate impact by behavior changing and social distancing change, the parameter λ is transmission rate from initial R_0 to final R∗ that is the point of social distancing, Roughly , most of region and countries should adopt social distancing strategies sooner than others, by detention of λ differences . The parameter β_0 is apprehended the advents of the disease, static of the region such as density in the specific region, thus, the β∗ parameter just like a social parameter for policy making, how strong social distancing that different locations are taking, either because of voluntary changes in individual actions respectively.

Finally, this section concluded that the spatial network has an essential role to attained in shape of disease (COVID-19) pandemic/ epidomlogical procedure and indicate the dynamic of infectious with respect to time interval. Our analytical results for novel COVID-19 disease in the Pakistan region including all provinces, GB , AJK, and the capital city Islamabad are expressed in results and discussion section.

III. FINDINGS (RESULTS AND DISCUSSION)

SPATIAL NETWORKING SIR-SEIR MODELS

At first step, we have explored performance of the theory of spatial network are described in§ 1 and 2 by equations and the diagrams 1 to 5 networking structure diagram and causes trees illustrations for lockdown/ quarantine by SIR-SEIR models .The results(table 1-3) and flowchart diagram 1 is clearly defined that infection probability(p) and recovery probability or removal (q) of the specific time interval infectious people depends on any of its near to a susceptible individual(**results are calculated by 10^6 million**), Also point out critical infectiousness ***p*** value to higher values although usually increases in the time duration of pandemic of COVID-19 ,all over the Pakistan region (Sind, Punjab , Khyber Pakhtunkhwa, Baluchistan, Gilgit Baltistan, Azad Jammu Kashmir and capital city of Islamabad) COVID-19 infectious probability value of p in the duration of 26th February to 26 May (last the month of March started lockdown/quarantine duration)and 27th May to 30th June 2020 (20th may to 07th June relaxation /reducing the lockdown and second week of the month of March is started smart lockdown period) and 1st July to 31st July (sensitive areas/ partial lockdown and others are followed social distancing /SOP not all while most of peoples are aware). Pandemic of COVID-19 is rapid all over the Pakistan specially Sind and Punjab province is very quickly monotonically increasing moved from first segment /interval to second interval, number of infectious people ,indicated that worst condition day by day(specially 27 May to mid of June) afterthought in final data segment in the month of July is shown decreasing on the base of the probability value (p> 0.1, risk attitude value 0.25, p> 0.1) disease speedily increase second segment is very quick . Finally, the pandemic started (from the city of Karachi) duration of 26 February to the month of June 2020 is shown speedily very high trend all over Pakistan province and including AJK, GB and capital city Islamabad in figure .1, Also, figure is confirmed Sindh and Panjab province is exponentially increasing pattern.

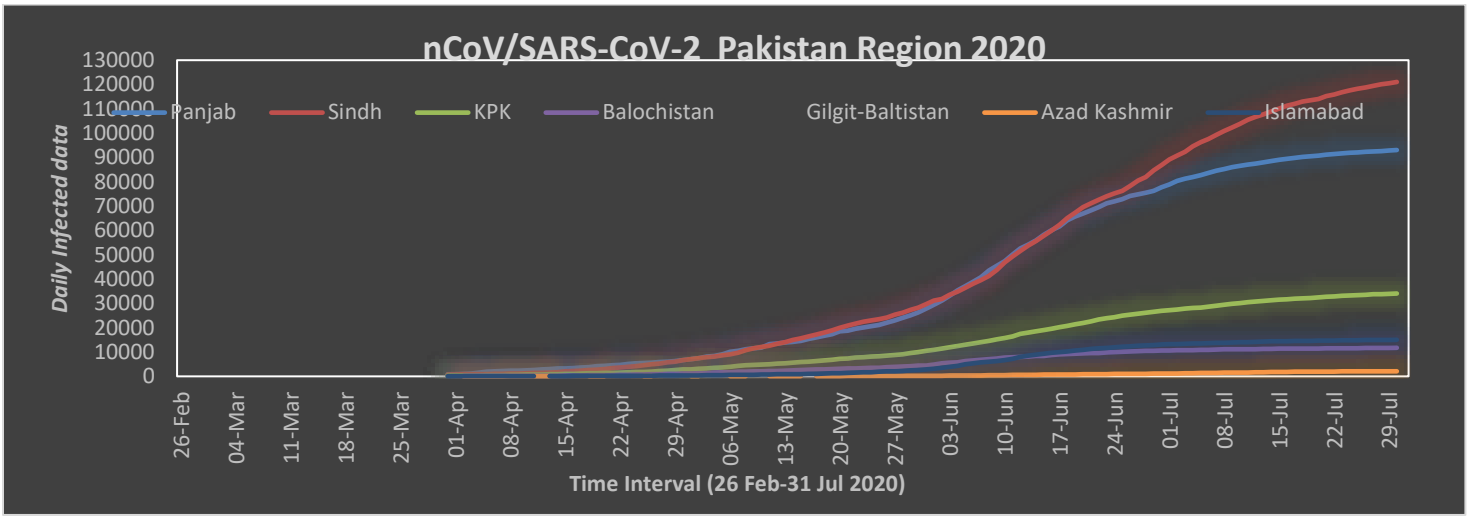


Figure 1. The pandemic of COVID-19 infectious people per day with and without lockdown/quarantine and social distancing intervals of our selected three segments in all regions of the country of Pakistan (from 26 February to 31 July 2020).

According to results, which is showed in table 1-3, the model parameters (β , α, λ , γ) values are seemed to be accurate for the scrutiny of COVID-19 pandemic in population of Pakistan. The model assumptions are mentioned underneath, therefore one of most requisite fact is must be mentioned at this point, by various sources (://doi.org/10.1101/2020.05.22.20110064doi), Acemoglu et al. 2020; Jiang et al. 2020; Riou and Althaus 2020) are reported the value of variable R range is diverging (1.4 to 3.9) from country to country, therefore we are computed value of R= 2.54(R = β/ γ) (see tables 1-3**)**.

Table 1. The Spatial Network SIR- SEIR models parameters with Lockdown, Quarantine, and Social Distancing in Pakistan Regions.

COVID- 19 Data spots	Infectious Probability	Recovery Probability	Parameters							
Region	$p>0.0001$	q	β	λ	α	γ	I/T_p	$I_t+R_t+D_t$	$\beta tSt * It/T_p$	βSI
Total Pakistan	0.00027	0.00009	1.46E-05	4.08E-09	1.1 e^{-03}	5.77E-06	2.70E-04	7.9 e^{-02}	8.67E-07	1.01E-04
Pakistan including AJK station	5.2E-05	2.4E-05	2.51E-06	1.32E-10	2.11E-08	9.88E-07	5.29E-05	3.01 e^{-04}	5.37E-10	2.17E-09

Province Baluchistan	0.00028	9.3E-05	8.43E-06	2.41E-09	4.08E-06	3.32E-06	2.86E-04	4.70E-03	2.98E-08	3.68E-07
Pakistan including GB station	0.00051	3.7E-05	1.84E-05	9.48E-09	2.95E-07	7.25E-06	5.14E-04	1.10E-03	1.17E-08	1.45E-08
Capital city Islamabad	0.00018	1.4E-05	4.50 $^{e-05}$	8.33E-08	2.85E-07	1.77E-05	1.80E-04	2.00E-03	8.44E-08	8.57E-08
Province of KPK	0.00023	7.3E-05	2.95E-05	6.87E-09	2.12E-05	1.16E-05	2.32E-04	1.12E-02	2.44E-07	8.68E-06
Province Punjab	0.00019	5.6E-05	8.35E-06	1.60E-09	1.30E-04	3.29E-06	1.91E-04	2.76E-02	1.76E-07	1.94E-05
Province Sindh	0.00049	0.00018	1.98E-05	9.73E-09	2.0 e^{-04}	7.80E-06	4.90 e^{-04}	3.23E-02	4.65E-07	2.23E-05

Population 10^6 million .; alpha risk attitude (0.25)

Table 2. The Spatial Network SIR- SEIR models parameters with lockdown, quarantine, and social distancing in Pakistan Regions.

Duration 27May to 30 June 2020										
COVID- 19 Data spots	Infectious Probability	Recovery Probability	Parameters							
Region	*p>0.0001*	*q*	β	λ	α	γ	I/T_p	$I_t+R_t+D_t$	βtSt * It/T_p	βSI
Total Pakistan	0.00072	0.000384	$3.79e^{-05}$	$2.75e^{-08}$	$3.29e^{-01}$	$1.49e^{-05}$	7.27 e^{-04}	2.391 e^{-01}	$5.84e^{-06}$	1.24e^{-03}
Pakistan including AJK	0.00021	0.000111	$1.63e^{-05}$	$3.54e^{-09}$	$4.62e^{-01}$	$6.42e^{-06}$	2.17 e^{-04}	$1.356e^{-03}$	1.43e-^{08}	5.80e^{-08}
Province of Baluchistan	0.00056	0.0000054	$1.64e^{-05}$	$9.26e^{-9}$	$3.26e^{-01}$	$6.48e^{-06}$	5.623 e^{-04}	$7.692e^{-03}$	$1.14e^{-07}$	1.40e^{-06}
Pakistan including GB station	0.00068	0.000536	$3.48e^{-05}$	$2.38e^{-08}$	$7.25e^{-01}$	$1.37e^{-05}$	6.86e-^{04}	$1.533e^{-03}$	$2.95e^{-08}$	3.67e^{-08}
Capital city Islamabad	0.00010	0.007003	$2.75e^{-04}$	$2.99e^{-06}$	$8.08e^{-02}$	$1.08e^{-04}$	1.086 e^{-02}	1.825 e^{-02}	$2.98e^{-06}$	3.02e^{-06}
Province KPK	0.00051	0.000295	$3.83e^{-05}$	$1.98e^{-08}$	$3.1e^{-01}$	$1.51e^{-05}$	5.16 e^{-04}	2.936 e-^{02}	$7.03e^{-07}$	2.49e-^{05}
Province Punjab	0.00050	0.000193	$3.23e^{-05}$	$1.6ee^{-08}$	$2.92e^{-01}$	$1.27e^{-05}$	$5.01e^{-04}$	$7.784e^{-02}$	$1.78e^{-06}$	1.959e-^{04}
Province Sindh	0.000127	0.000799	$5.31e^{-05}$	$6.79e^{-08}$	3.62 e^{-01}	$2.09e^{-05}$	1.27 e^{-03}	1.00 e^{-01}	$3.24e^{-06}$	1.554e-^{04}

Population 10^6 million .; alpha risk attitude (0.25)

Table 3. The Spatial Network SIR- SEIR models parameters with lockdown, quarantine, and social distancing in Pakistan Regions.

Duration 1 July to 31 July 2020									
COVID- 19 Data spots	Infectious Probability	Recovery Probability	Parameters						
Region	*p>0.0001*	*q*	β	λ	α	γ	I/T_p	$I_t+R_t+D_t$	βtSt * It/T_p
Total Pakistan	0.0003	0.00069	1.88E-05	5.83E-09	2.241	7.42E-06	3.09 e^{-04}	2.14E-01	1.23E-06
Pakistan including AJK station	0.00024	0.00026	1.50E-05	3.69E-09	1.101	5.93E-06	2.44E-04	2.11E-03	1.49E-08
Province of Baluchistan	0.0001	0.00078	3.08E-06	3.17E-10	7.613	1.21E-06	1.02 e^{-04}	1.09E-02	3.90E-09

Pakistan including GB station	0.00052	0.0005	5.73E-05	2.98E-08	0.976	2.25E-05	5.20E-04	1.30E-03	3.69E-08
Capital city Islamabad	0.00208	0.00524	9.25E-05	1.93E-07	2.512	3.64E-05	2.089 e^{-03}	7.486 e^{-03}	1.94E-07
Province KPK	0.0002	0.00043	1.77E-05	3.72E-09	2.086	6.98E-06	2.10E-04	2.33E-02	1.32E-07
Province Punjab	0.00015	0.0005	8.77E-06	1.33E-09	3.277	3.45E-06	1.53E-04	7.22E-02	1.47E-07
Province Sindh	0.00076	0.00133	4.47E-05	3.39E-08	1.755	1.76E-05	7.60E-04	1.01E-01	1.62E-06

Population 10^6 million.; alpha risk attitude (0.25)

The numerous parameters values of the model also computer by formularized, Transition rate T(t) , Contact rate and Fraction Contact between infectious and susceptible (*SI*/*N*) and various above mention parameters also specified the SIR-SEIR model parameters are absolutely calibration. The epidemic size and probability of infectious *p* effect to reducing social distancing, after relaxation of lockdown in this duration COVID-19 expanding increasing with pandemic size, the COVID-19 disease is attacking due to high value of *p* as compare to before 20th May 2020, whereas in the absence of social distance it expanded the size and duration of the epidemic(see table 2).the final data segment with social distancing duration from 1st July to 31 July 2020.

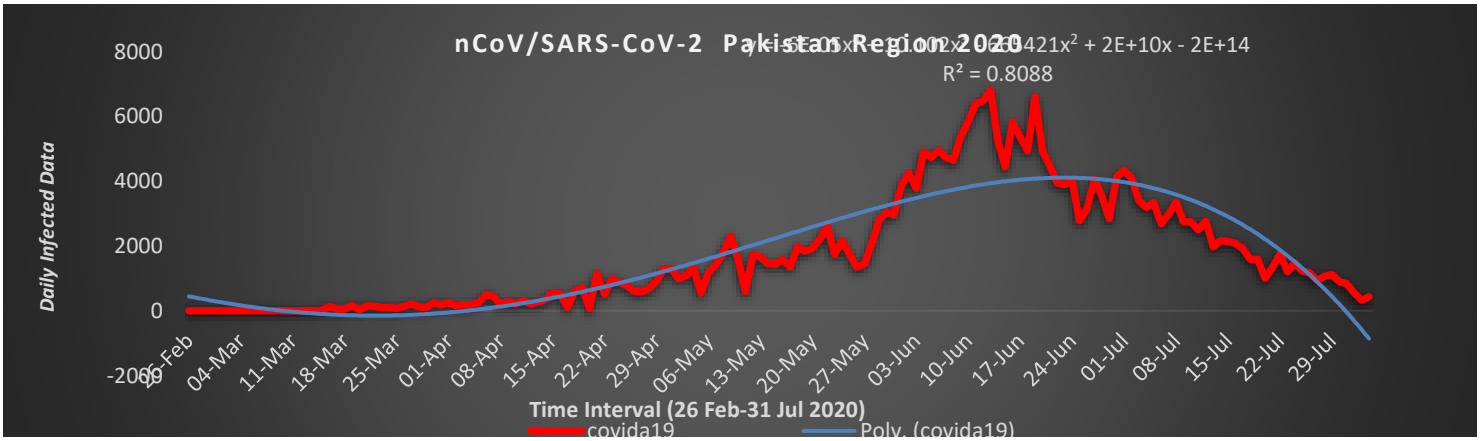


Figure2. The 4th degree polynomial acts included lockdown/quarantine and social distancing periods in the pandemic of COVID-19 over Pakistan regions from 26 Feb to 31 July 2020.

Figure.2 is indicated that infectious people per day with and without lockdown/quarantine and social distancing intervals of from 26 February to 31July 2020, respectively. The figure is analyzed by 4th degree polynomial function for COVID-19 infected number of people are increasing mid of June, due to lack of awareness and breakage of social distancing.

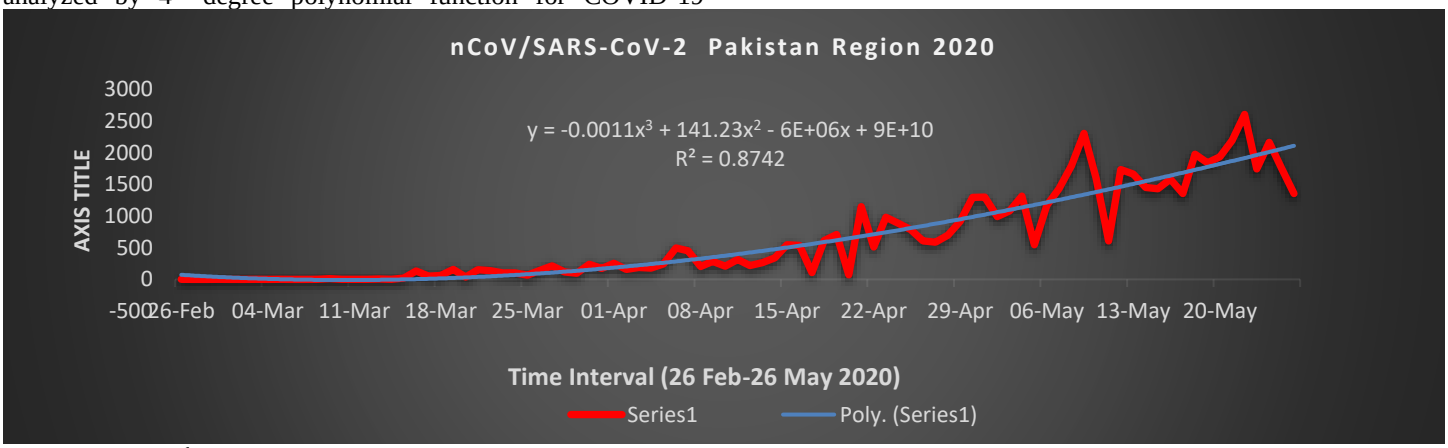


Figure 3. The 3rd degree adequate polynomial comprised lockdown/quarantine in pandemic of COVID-19 over Pakistan regions from 26 Feb to 26May 2020.

Figure 3 is indicated in the COVID-19 spread for first segment data (set (26 February to 26 May)by the 3rd degree polynomial function

applying with in the duration of lockdown/quarantine and breaking lockdown (after second week of May2020) and didn't tracked SOP overcrowding in markets and public places due to Muslims festival Eid -e- Fithar.

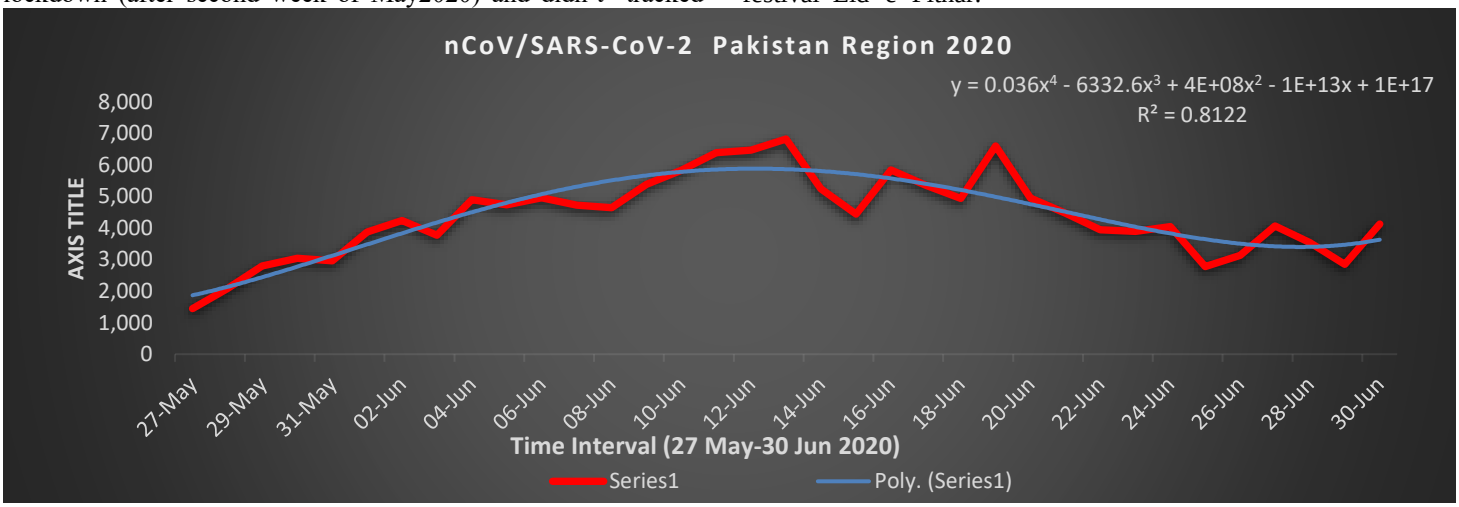


Figure 4. The 4th degree polynomial acts relaxation period of lockdown beside breakage of social distancing in the pandemic of COVID-19 over Pakistan regions from 27 May to 30 June 2020.

Figure 4, The 4th degree polynomial function is shown highly increasing trend by breakage lockdown/not followed social distancing is clearly seen (13th June is infectious peak highest individual cases 6,825 after that third week of June behavior was going to moderated) in second segment (27th May to 30th June).

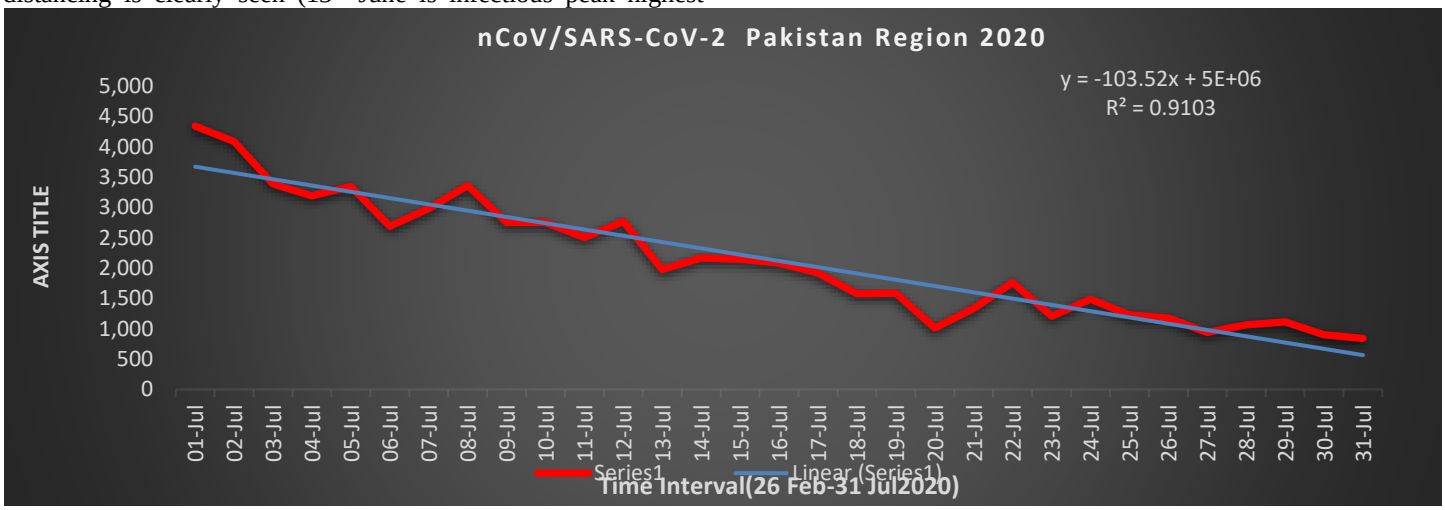


Figure 5. The pandemic of COVID-19 with social distancing transformed rapidly polynomial to Linear Trend from (1st July to 31 July 2020).

Figure 5 is interpreted the social distancing effects in the last segment of our selected interval (1st July to 31st July), which is displayed a decrease of the spread of disease and reducing behavior from polynomial function to linear function. The final data segment is indicated the high value of R^2(0.94108) as compared to other intervals, it is also verified that the overall spread pattern down to 1-july 2020 has been changed from polynomial to decline flattening linear curve.

The parameters of SIR model is estimated the peak of the pandemic in time expected infectious rate and then estimated future trends on the reliant of data values , At this juncture, we are stalked a analogous approach to implement the SIR – SEIR time dependent Model, Novel COVID-19 epidemic is a new disease all over the world, our country situation would not be accurate prediction of a rational number of infections and the upcoming peak of the pandemic, One main reason is deficient of testing (0.3% testing(per 220 million people) on the dated 30th June 2020,While COVID-19 (last week of June to onwards) data are shown the fluctuating growing and decaying behaviors, the adequate prediction of infectious are flatten and decline the peak of the disease trend. the infectious people with and without social distancing besides lockdown for all over data segments are determined by parameters (table 1-3) respectively.

The Effect of Social Distancing with People Contacts reducing proportionality: Calibrating the Alpha-Beta ($\alpha I, \alpha D$ and $\beta 0$) Parameters

To summarize, above mention parameters-based results are suggested that intended social distance is main controlling apparatus, when the COVID-19 pandemic has activated to reach its peak, and the social distance should be lectured. Necessary from the initial time of the pandemic. Concerning, the infectious *I* and recovered *R*, the transition rate of change is considered equal to the individual's number of infectious cases(γI), if an individual is infectious for time period D, then $\gamma = 1/D$. which is *I* (this will

not be the only number of recovered and attained immunity from the COVID-19, although a massive number of deaths as well). Here we are focused to parameters in contacts reducing equation (11) of SIR model β(t), $\alpha_D(t)$that measures the transmissions per unit time and γ(t) that measures the recoveries per unit time, Correspondingly,the number of days contacts are infectious γ^{day} = 0.2 or 5 days , θ=0.1 indicating 10 more days by the disease before it resolves , δ is current death rates and parameter β value are estimated by (R=β/ γ).), the reducing people contacts proportionally to number of infectious people with effect of social distancing are computed ,the social distancing final data interval (1st July to 31st July 2020) carried out appropriate function equations of total data of $\mathbf{P_{akistan}}(\log(0.0000188) = \log(0.508) - \alpha_I \times 0.065676)$ and $\mathbf{P_{akistan}}$ $(\log(0.0000188) = \log(0.508) - \alpha_D \times 0.001575)$ with values of α_I and α_D .The reducing people contact functions model for proportions of infected people, another reducing contacts function model according to the current death rate, whenever we have not identified how many people are infected at certain time, due to lack of testing are also calculated (see table 4 $\gamma I, \alpha_I, \alpha_D$) respectively.

Table 4. Reducing people contacts proportionally to number of infectious people with effect of social distancing in duration (1st July to 31 July 2020)

Location	Δ	$\beta_0(t)$	R_0	α_I	α_D	γ^{day} I
Pakistan	2.398	0.508	2.54	6.745	2.812	0.013135
AJK	2.421	0.508	2.54	0.00395	0.012591	0.000198
Baluchistan	1.118	0.508	2.54	0.00579	0.11468	0.000253
GB	4.342	0.508	2.54	0.00166	0.01834	0.000129
Islamabad	1.741	0.508	2.54	0.00057	0.134	0.000424
KPK	3.326	0.508	2.54	0.00027	0.0234	0.001492
Punjab	2.269	0.508	2.54	0.20843	0.121	0.003359
Sind	2.315	0.508	2.54	0.21943	0.132	0.007279

IV. CONCLUSION

The present study is investigated the problem of COVID-19 pandemic in the country of Pakistan including all provinces (Sind, Punjab , Khyber Pakhtunkhwa, Baluchistan, GB ,AJK and capital city of Islamabad .The Spatial network models with Quarantine, Lockdown and effect of Social Distancing are described, our mathematical spatial network models investigation are suggested and inveterate, whenever any effectual medication or vaccines for COVID-19 are not accessible, social distancing is the only one why for control and decreasing the pandemic of COVID-19. The inclusive population are considered as susceptible circumstances. The SIR-SEIR networking results are found that the COVID-19 disease progresses rapidly, then is limited by the declining, susceptible class go to exposed class. The exposed class is moved to infected and infected people are detecting for recovery people, fertility rates always asymptote by a constant number of infectious and death rates per day. The Social-distancing are modeled by reducing the contact rate with infection coefficients, the α, β, γ, λ, γ^{day} I, α_I and α_D parameters are performed an important role in spread assessment of COVID-19 disease with and without lockdown or partial/smart lockdown as well as social distancing scenario. The total number of infectious and peak infection proportion are also estimated. Finally, the social distancing parameter is developed a theory that the limit $\gamma \to \infty$ then the absents of uninfected decreasing rate is $1/R_0$.The SIR- SEIR parameters results are proved that self-isolation can assumed the COVID-19 pandemic curve, although it is reduced to its peak, also shown that allocating the social distancing is very effective at flattening curve.

The peaks of infectious COVID-19 second segment (27 May to 30 June 2020) in figure 4 , also verified speedily pandemic of COVID-19 disease due to overcrowding and breakage of social distancing, SIR-SEIR parameters results obviously adequate and confirmed contacts reduced proportion with social distancing, concluded that after contact of infected people , disease symptoms are shown within five days, reproduction rate R= 2.54 is also clarify in Pakistan region in selected data segments that is why infected polynomial 4th degree (R^2= 0.812) is also indicated breakage social distancing disease is spread in second segment. social distancing will endure one of the main procedures to contest disease pandemic, until a vaccine is commonly available. Our SIR-SEIR networking results are support planners irritating to deliberate the pandemic of COVID-19 to decrease the peak demand on health services although avoiding the entire shutdown of industry.

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AUTHORS

First Author – **Muhammad Ilyas**, PhD, Department of Mathematics, Government College University Hyderabad, Sindh, Pakistan dr.m.ilyas@gcuh.edu.pk
Second Author – **Shaheen Abbas**, PhD, Laboratory for Applied Mathematics and Data Analysis (LAMDA) Mathematical Sciences Research Centre, Federal Urdu University of Arts, Sciences and Technology, Karachi, Pakistan
email address. shaheen.abbas@fuuast.edu.com
Third Author – Afzal Ali, M.Phil. (in process), Laboratory for Applied Mathematics and Data Analysis (LAMDA) Mathematical Sciences Research Centre, Federal Urdu University of Arts, Sciences and Technology, Karachi, Pakistan afzal.shigri6616@gmail.com

Fourth Author- Syed Akhtar Raza Department of Computer Science Federal Urdu University of Arts, Sciences and Technology, Karachi, Pakistan. akhtar@fuuast.edu.pk

Fifth Author – Wajid Ali Department of Mathematical Sciences Karakoram International University Gilgit. Pakistan wajid.ali@kiu.edu.pk
Correspondence Author –
Shaheen Abbas, PhD, Laboratory for Applied Mathematics and Data Analysis (LAMDA) Mathematical Sciences Research Centre, Federal Urdu University of Arts, Sciences and Technology, Karachi, Pakistan
email address. shaheen.abbas@fuuast.edu.pk