Article:	**An Assessment of the Smart COVID-19 Approach to Lockdown and its Empirical Evidence**

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An Assessment of the Smart COVID-19 Approach to Lockdown and its Empirical Evidence

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Abstract

COVID-19 is a new and contagious disease that has changed human lifestyle and habits globally according to the directions provided by the World Health Organization (WHO). Until some authentic remedy or vaccine becomes available, every country is providing instructions to its public to follow precautionary measures. These measures may include lockdown, social distancing, restricting movement, and educating public about COVID-19. Lockdown is the most applied and successful way to control the virus spread and it remains helpful in curtailing the spike. However, it adversely affects developing countries like Pakistan. All types of lockdown disrupt the life of the poor and the middle class. In this paper, an intelligent-smart approach is suggested for developing countries as against complete lockdown to handle the pandemic. This approach will show long-term results needed for controlling COVID-19 without creating any major disturbance in the economy. In this paper, evidence based approaches were used to evaluate the short-term and long-term effects of the daily increasing number of cases of COVID-

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19 in Pakistan. The results showed that Sindh, which has the maximum number of COVID-19 cases, is better in implementing smart lockdown as compared to other administrative regions of Pakistan. As the risk of the second wave of COVID-19 is enhanced, it would be effective to continue the intelligent-smart approach with mild SOPs to avoid the disastrous effects of COVID-19 in the future.

Introduction

Severe acute respiratory syndrome (SARS) is a set of diseases related to different types of coronaviruses reported in the last two decades (Zhou et al., 2020). A new wave of the epidemic started on December 12, 2019, in the city of Wuhan, China by a novel coronavirus (2019-nCoV), which is a new virus in the same SARS-CoV family (Zhou et al., 2020). Its spread was initially linked with a seafood wholesale market where a large number of patients with pneumonia were reported (CDC, 2020b). Its first structural analysis put it like 85% identical with SARS-CoV and closer to coronaviruses already found in bats (CDC, 2020b). It can cause different diseases related to the respiratory system ranging from the common cold to severe SARS (Masuda & Holme, 2013). The most common symptoms of COVID-19 include nausea, hypotension, vomiting, severe asthenia, neuralgia, myalgia, headache, olfactory, gustatory dysfunction, fever, worsening acute cough, dyspnea, and pneumonia (Poloni et al., 2020). The symptoms of COVID-19 are similar to the symptoms of influenza, so patients suffering from influenza may get infected with COVID-19 (Dua, Javana, Nugenta, Cowlingb, & Meyers, 2020). There may be no apparent symptoms initially but within 3-6 days of the incubation period (Chan, et al., 2020) the patient begins to show actual symptoms. It slowly makes the respiratory system non-functional and finally leads to death (Zhou et al., 2020). It was declared as a pandemic respiratory disease that can be transmitted from person to person (CDC, 2020a; CDC, 2020b) and can only be controlled by following precautionary measures suggested by (WHO, 2020).

In Pakistan, the number of new cases was increasing rapidly during May and June. The overall trend of cases in Pakistan on August 17, 2020, is shown in Table 1, with the region wise daily cases, deaths, and recoveries during the last months of the pandemic. Table 1 shows that the Sindh province has 94.8% recovery rate which is the maximum recovery rate, while Gilgit-Baltistan has a minimum recovery rate of 85.58%.

Table 1

COVID-19 Cases Region Wise on August 17, 2020 (*Ministry of National Health Services (*MNHS), 2020)

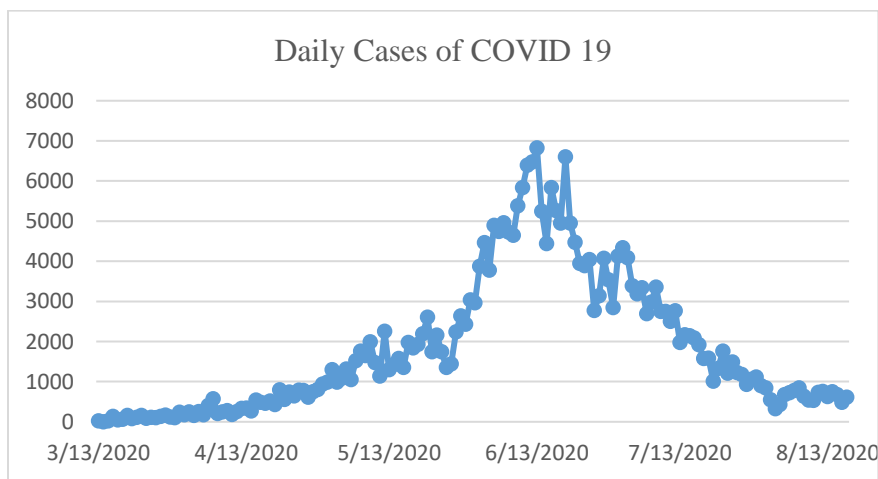| Pakistan Regions	Cases (%)	Deaths (%)	Recoveries (%)
Punjab	95,611 (32.99)	2,185(2.26)	88,861 (92.93)
Sindh	126,425(43.62)	2331(1.84)	119,849(94.80)
KPK	35,337 (12.19)	1,239(3.51)	32,522 (92.03)
Balochistan	12,321 (4.25)	138 (1.12)	11,153 (90.52)
Gilgit-Baltistan	2,538 (.8757)	61 (2.41)	2,172 (85.58)
Azad Kashmir	2,199 (.7587)	61 (2.77)	2,002 (91.04)
Islamabad	15,401 (5.314)	175 (1.14)	13,430 (87.20)
Total	289,832	6190	269989

Figure 1. Daily cases of COVID-19 in Pakistan

The polynomial model explains that cases are increasing on a daily basis but the curve shows a decreasing trend after June 2020. It shows that total cases in Pakistan are 289,832 with 2.14% death

rate and 93.15% recovery rate (MNHS, 2020). COVID-19 transmission was first reported in Pakistan when Pakistani pilgrims were forced to return from Iran and the situation was mismanaged in many ways. At the Taftan border, where more than 3000 pilgrims were kept in miserable conditions without any medical support ("Squalid Taftan quarantine camps," 2020). The government shifted them to other provinces without any planning which caused the transmission of the virus throughout the country. Figure 2 shows the number of monthly cases in Pakistan. It shows that June was the most affected month from Covid-19 and maximum patients were infected during this month.
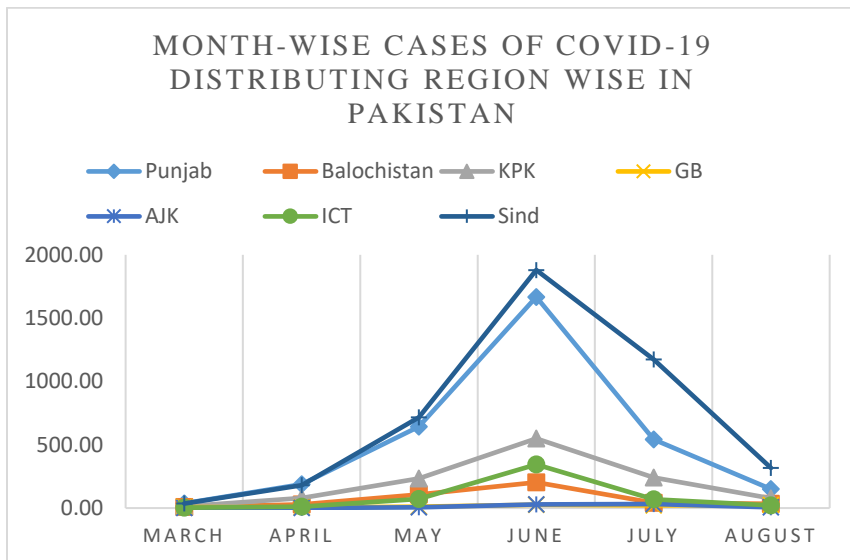

Figure 2. Region wise monthly cases of Covid-19 in Pakistan

The government imposed a complete lockdown without preparation on March 15, 2020 for three weeks which had a significant economic impact. Rather than strictly following the lockdown policy, after two weeks various businesses were allowed to operate partially. After one week, the government revised its decision and announced smart lockdown in specified localities where infections were occurring (Rukh, Nafees, & Khan, 2020b). This reversal in the reopening policy indicated the lack of seriousness by the government in controlling the spread of the virus. From Fig. 1, it is concluded that there has been no benefit of more than a month long lockdown in Pakistan due to mismanagement and

various lockdown violations. It also shows 8,825 new cases on June 13, 2020 which remains the highest single day figure in Pakistan.

The implementation of lockdown during a pandemic is not an easy decision to make. It would be effective only if it is planned properly. In Pakistan, the implementation of lockdown was not a strategically wise decision because of the slow economy, low earnings, high inflation, and a diversified social structure. The life of the poor was greatly affected and it would not be restored even after a year. COVID-19 has affected Pakistan severely and the lockdown has further intensified this adverse situation (Chohan, 2020).

Instead of complete lockdown, the smart lockdown was proposed by (Raza et al., 2020) which constitutes selective lockdown in the infected areas only (Abdullah, ul Islam, Mehmud, & Qazi, 2020). It is a beneficial strategy as compared to complete lockdown ("Coronavirus in Pakistan", 2020). In this paper, an intelligent-smart approach is suggested which is a combination of smart-lockdown, business SOPs, relief package, and the healthcare system.

1.1. Objectives of the Study

The objectives of this study are as follows:

1) To investigate the incidences of COVID-19 across the administrative regions of Pakistan.
2) To investigate the use of an intelligent-smart approach instead of complete lockdown.

Section 2 reviews the literature about controlling the pandemic situation. The proposed intelligent-smart approach is discussed instead of complete lockdown in Section 3. Results and discussion are given in Section 4.

2. Literature Review

A pandemic is caused by an infectious disease that can put human health at risk and normally spreads over social networks of people or animals. The effects of infectious diseases can be controlled by restricting interaction among people (Masuda & Holme, 2013). The epidemic of African cassava mosaic disease in 1988, caused by

whitefly-transmitted geminivirus in Uganda, was controlled by implementing appropriate technologies to control the disease (Otim-Nape, Bua, & Baguma, 1994). Epidemics could be effectively controlled using proper quarantine, screening, and health promotion campaigns (Behncke, 2001). Intensive testing, isolation, and limiting contacts were used as measures to control the transmission of COVID-19 in Singapore and Hong Kong, whereas countries without testing experienced greater spread of the virus. Social distancing slows down the virus spread and indirectly reduces the risk of collapsing the healthcare system (Kissler, Tedijanto, Lipsitch, & Grad, 2020). Fear and discrimination increase anxiety, uneasiness, and unsafe feelings, so removing them will constitute frontline defense against COVID-19 (Ren & Chen, 2020).

Complete lockdown is used to control an epidemic in a certain situation, such as the Wuhan lockdown was useful in controlling the spread of the virus to other parts of the country. However, intensive screening and social distancing must be implemented to control the local spread (Peng, Liu, Ni, Cui, & Du 2020). A strict one-month lockdown in France showed an 83% reduction in predicated deaths, whereas 23% of the French population was infected by the novel coronavirus before March 19, 2020 (Roux, Massonnaud, & Crepey, 2020). So, the effectiveness of the lockdown largely depends upon the intensity of the virus spread and planned activities. In Malaysia, the government adopted a limited lockdown approach to control COVID-19 without planning and it resulted in socioeconomic disruption (Salim et al., 2020).

Sardar, Nadim, Rana, & Chattopadhyay (2020) mentioned the effect of lockdown in various states of India and suggested lockdown only in case of a higher mortality rate. If lockdown is required in case of a higher mortality rate or due to an increasing number of positive cases then it must be pre-planned; otherwise, it will affect adversely the economy and human welfare (Umoh, et al., 2020). Lockdown is a period needed to prepare the health care system to understand the clinical methods used to treat the patients effectively; otherwise, there will be no benefit of lockdown in the future (Wilder-Smith & Freedman, 2020).

Smart lockdown is an effective solution for developing countries. In the case of Pakistan, it yielded fruitful results while balancing the situation caused by the spread of COVID-19 and the concerns regarding the economy (Asghar, Batool, Farooq, & Rehman, 2020). After relinquishing complete lockdown, it would be a wise strategy to adopt smart lockdown to revive the economy (Vega, 2020).

With the end of lockdown in various countries after a decreasing number of cases, the second and third waves of COVID-19 have been observed in the United States (Solis, Franco-Paredes, Henao-Martínez, Krsak, & Zimmer, 2020), South Korea, Iran, and Italy (Strzelecki, 2020).

3. Methodology

3.1. Intelligent-smart Approach

It is a combination of smart lockdown with certain SOPs to allow people to operate businesses following certain techniques to control COVID-19, as complete lockdown would not be feasible in the context of Pakistan (Farooq, Khan, & Khan, 2020). The government allows some businesses to operate during smart lockdown (Mahmood, 2020). In this section, different techniques are discussed to implement this approach and its success depends upon its accurate implementation.

3.2. Why an Intelligent-smart Approach?

There are several reasons to implement the proposed intelligent-smart approach against complete lockdown.

3.2.1. Social norms and living style. Pakistan had a population of 212.82 million in 2018 (Ministry of Finance, 2019) and it is included in the most populous countries of the world. Population density at 275.29 persons per square kilometer is much more in Pakistan than that of the United States, where it is only 35.76 persons per square kilometer (World Bank, 2018). The living style is mostly family based, with 6.45-6.89 persons living under the same roof in 2017 (Rana, 2017). So, community containment is not possible for a long period and it becomes difficult to restrict a large number of people in small size homes. Community containment proved to be an effective way to combat the COVID-19 spread in

China although it is not easy to implement on a large population. It includes avoiding public and social gatherings, restricting public movement, applying lockdown, wearing a face mask, and adopting work-from-home policy (Wilder-Smith & Freedman, 2020). It rapidly impacted the mortality rate and return benefits in monetary terms in the United States; however, in Pakistan, various social norms hinder such measures (Greenstone & Nigam, 2020). People always like social gatherings and mostly hug and shake hands (Barrech, 2020). Grandparents hug and make close contacts with children which is the major reason behind the high incidence of COVID-19 cases in older people. Indeed, 41% of deaths in Italy are reported to be of people aged 80 years or above (Poloni et al., 2020). Maintaining six feet distance recommended by WHO (WHO, 2020) is not an easy task to implement in a crowd and several challans have been issued due to the violation of COVID-19 regulations (Mahmood, 2020).

3.2.2. Relief package for population living below the poverty line. In Pakistan, more than 24.3% of the population was still living below the national poverty line in 2015-16 (Ministry of Finance, 2016). Therefore, it would be difficult to cope with the situation of lockdown. The number of people living below the poverty line will increase in developing countries due to COVID-19 (World Bank, 2020).

In Pakistan, the average monthly income was 18,754 PKR in 2018 (CEIC, 2019), whereas in the United States it was $3714 in 2017 on average (Luther, 2018). The average household per capita income was $650.64 in 2016, whereas household per capita expenditure was $594.72 which shows little saving (Christie, 2014).

It would become difficult for the government to provide support to those affected because of lockdown and living below the severe poverty line. Developing countries can provide only a small amount as relief package. The federal government of the United States announced $484bn (Roberts, 2020), whereas the government of Pakistan announced 14bn rupees in the form of a relief package providing 12,000 rupees per month to people living below the severe poverty line (Nishtar, 2020; Rukh, Nafees, & Khan, 2020b). This

small relief package would never be able to retain people within their homes, as it cannot cover their household expenditures.

3.2.3. Business shutdown. All businesses except food manufacturers and suppliers were locked entirely which immediately squeezed all surplus resources. Therefore, these businesses will be affected due to the novel coronavirus and there would be an increase in unemployment from 5.8% to 8.1% in the next 18 months (Siddiqui, 2020). After a one-week lockdown, they had to run their businesses by violating lockdown as no relief package was given to them. Tourism was severely affected without any tourist activity (Rukh, Khan, & Nafees, 2020a).

Pakistan's economy largely depends upon small and medium enterprises (SMEs) and cottage industries. SMEs which represented 90% of all private businesses and held 78% of non-agricultural employment in 2005 (Dar, Ahmed, & Raziq, 2017) were affected mostly due to lockdown. Their workers are normally daily wagers. Even the owners of SMEs have limited capital that can sustain them for a few days only. Seven million daily wagers were affected by the lockdown (Nafees & Khan, 2020) which resulted in large scale unemployment (Siddiqui, 2020). Some organizations laid off their employees to reduce cost without regarding the decision of SBP which allows them to borrow at 6% to pay salaries due to the fact that most of these businesses are not income tax filers ("SMEs, markets want relaxation," 2020).

3.2.4. Brick-and-mortar business. E-commerce, as a solution to do business in lockdown, is in its initial stage in Pakistan due to limited facilities and government support (Ahmad, 2017). A large part of the economy is based on brick-and-mortar businesses, so it becomes difficult to perform business activities during lockdown. Online businesses in Pakistan are mostly click-and-mortar, which were also affected because of lockdown.

3.2.5. Shortage of food and high cost of living. The availability of food is not possible for a long period without violating the quarantine. Due to lockdown, the production of food items and the supply chain system remain severely affected. Lockdown in Tokyo, Japan affected the entire economy of Japan. More than 80% decline in production is expected in the city after a one-month lockdown,

which will also affect the regions without lockdown (Inoue & Yasuyuki, 2020).

The inflation rate in Pakistan is already 12.93% which leads to price hikes amid the already declining earnings of the people due to the lockdown (Javed, 2020). The slow growing economy of Pakistan which was growing only at 3.3% annually (Ministry of Finance, 2019) will be further disturbed due to lockdown. The demand for different products has increased tremendously in the current situation, so vendors are charging higher prices.

3.2.6. Religion. Due to local norms and because of the involvement of religious associations in applying the rules for mosques in Pakistan, the government has little control over religious places. So, the chances of disease transmission are higher in mosques and at other religious places.

3.2.7. Psychological factor. The uncertain COVID-19 situation increases the stress level, confusion, and frustration (Mukhtar, 2020). It becomes more critical for students and nearly 50% of them are affected due to the high stress level (Raja et al., 2020). People in Pakistan think differently as compared to most people in advanced countries. They do not believe in the government and refrain from following the SOPs due to the gap between the rulers and the public (Barrech, 2020).

3.3. Components of an Intelligent-Smart Approach

The working of the proposed intelligent-smart approach depends upon various components described in this section.

3.3.1. Smart lockdown. The main component of the intelligent-smart approach is smart lockdown, which is a way to lockdown those localities where positive cases are increasing rapidly. Businesses including cottage industries and SMEs must follow the SOPs designed by the government to perform business activities (Asghar et al., 2020). People are allowed to move while wearing a face mask and keeping social distance. Pakistan successfully imposed smart lockdown in 227 different locations in major cities ("Pakistan's 30 cities", 2020).

3.3.2. Educate the public. To educate and train people to face the COVID-19 situation is the most effective element of an

intelligent-smart approach. It is important to provide proper information about coronavirus and the cause of its spread, as well as adopting cleanliness and following SOPs to conduct business. Instructions should be given to avoid crowded areas while maintaining the recommended distance and wearing a face mask. People should show patience instead of creating panic. It is important to train people about handling COVID-19 patients and to know that it is a recoverable disease as nearly 97% of COVID-19 patients recovered in Pakistan (MNHS, 2020).

3.3.3. Understand social distancing and quarantine. Social distancing must be implemented to avoid close contacts to curtail virus transmission and to maintain the recommended distance while performing business operations. It would be a better strategy than a complete lockdown. It is important to isolate the COVID-19 positive people from the rest of the populace to avoid its transmission, so the concept of quarantine becomes crucial to identify and treat patients effectively. Self-quarantine is only preferable if one feels mild symptoms; otherwise, the government managed quarantine centers must be preferred.

3.3.4. Religion. In most religions, collective worship is preferable. However, Islam allows one to pray at home instead of mosques when there is heavy rain or storm (Sahih Muslim, 97: 1487-1495). Islam obligates prayer five times a day with the complementary practice of *wudu* which includes the washing of face, hands and feet. Moreover, the Holy Prophet induced cleanliness as half of the faith of a Muslim (Sahih Muslim, 97: 1487-1495). So, performing prayer five times a day will help to eliminate the novel coronavirus; otherwise, one must follow the hand-wash instructions given by WHO (WHO, 2020). Strict SOPs must also be followed while performing religious activities.

3.3.5. Extending hospital capacity. In developing countries hospitals are already working at their full capacity, so they cannot handle the spike in the number of patients due to the novel coronavirus. Germany failed to overcome COVID-19 despite having the highest number of ICU beds in the world (Becher & Frerichs, 2020). It is also difficult to provide fully isolated wards and quarantine centers. One must keep in mind the limits of

hospitals, so self-care becomes the core element of the treatment. Hospitals must follow social distancing to effectively reduce the mortality rate, as (Wilder-Smith & Freedman, 2020) recommend to extend the capacity of hospitals and medical facilities. Hospitals must be equipped with the proper equipment and given authority to order the necessary equipment if needed.

3.3.6. Intensive testing. It should be performed without any discrimination on an urgent basis to identify COVID-19 patients. It would be better to provide free testing facilities to the public at large to avoid the hidden risk of COVID-19 (Ai et al., 2020). Bhutan performed the highest number of tests in South Asia; therefore, there have been fewer cases in Bhutan as compared to India and Pakistan which implemented lockdown strategies without intensive testing (Fliegauf & Ayres, 2020).

3.3.7. Better implementation of relief package. The relief package must be managed properly by transferring money to the needy. It would be better to distribute its benefits to all by cutting off utility bills, relaxing bank interest, and providing free testing. State Bank of Pakistan (SBP) offered a one-year moratorium on loan schemes during which the banks are eligible only to receive markup and not the principal amount, although it would be better to receive the actual capital instead of the markup. SBP also offered 6% loans to organizations paying taxes, although it would be better to give interest free loans without any discrimination. Due to these relief packages, government debt will increase in the coming months (Asghar et al., 2020). However, it would be compensated by international COVID-19 aid.

3.3.8. Release tension. It is important to release tension and relieve the psychological stress experienced by the population at large by making people aware that COVID-19 is a curable disease (Mukhtar, 2020). So, people with positive symptoms must come forward to quarantine themselves instead of hiding it. They must be educated about its psychological and behavioral effects. People should be absolved from the fear of the non-availability of hospitals and psychological support should be provided to infected families (Banerjee, 2020).

3.3.9. Centralized information source. It is also important to have a centralized information source available to share precautionary measures and valid information about COVID-19 with healthcare practitioners to avoid misinformation and to reduce their stress level while treating patients (Mukhtar, 2020). It should also provide standardized guidelines about isolation, self-quarantine, social distancing, and safety measures. The government has already created a National Command and Control Centre (NCCC) about COVID-19. Moreover, it also imposed restrictions on news channels to transmit only the information provided by NCCC to the general public.

3.3.10. Encourage online business. A major change due to COVID-19 is the way of doing business. Indeed, a traditional brick-and-mortar type of business is not easy to operate due to business SOPs. It is necessary to conduct all business operations through online networks. Digital business operations are possible in the lockdown. Otherwise, click-and-mortar types of businesses must be implemented. Educational institutes are teaching their students through online collaboration tools. Software houses, call centers, and TV channels are conducting their businesses by following work-at-home policy.

3.4. Data Source

To analyze the effect of COVID-19 in Pakistan, the collected data includes the number of new cases, number of deaths, and the number of recoveries on a daily basis from March 13, 2020 to August 17, 2020. The data was downloaded from the COVID-19 Health Advisory web site (MNHS, 2020).

3.5. Descriptive and Inferential Statistics

Descriptive statistics include measures of location and measures of dispersion which are reliable tools to check central tendency and variations within the data. Graphical presentations were used to see the increasing and decreasing trends of the COVID-19 cases region-wise as well as month-wise. Several statistical techniques were performed through inferential statistics like polynomial models, correlation, and covariance analysis. In these cases, several situations have a linear equation between two variables that would

be optimal for the relationship to be used. However, there are also several cases in which, rather than linear, the relationship between two variables will be curvilinear. The fluctuation, for instance, raises the cases in the regions of coronavirus patients.

Models with nonlinear interactions are more complex than models that exhibit only linear interactions. While complicated models are often appropriate, for many reasons, decision makers should use them with caution. For Instance, the model

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X^2 + \varepsilon \qquad 3.1$$

Eq. 3.1 displays polynomial models of the second order for various areas of Pakistan. While polynomials of all order occur in many fields, polynomials of the second order are probably the most common in the literature. The second degree polynomial models output is given in table 5.

4. Estimation and Results

Table 2 shows that Sindh province has more cases on average. Moreover, it shows a high variation in the data. The total number of patients is 289,832 (MNHS, 2020), which is the highest number of patients region wise in Pakistan, with 2.14% mortality rate and 93.15% recovery rate.

Table 2

Descriptive Statistics of Region Wise Covid-19 Cases in Pakistan till August 17, 2020

Regions	Mean	Standard Deviation	Min.	Max.	Total cases
Punjab	605.1329	645.6573316	0	2705	95611
Sindh	800.1582	739.9576036	2	3038	126425
KPK	223.6519	201.0636344	0	1035	35337
Balochistan	77.98101	89.71699819	0	501	12321
GB	16.06329	12.40078256	0	55	2538
AJK	13.91772	16.5771561	0	83	2199
ICT	97.47468	140.9825711	0	771	15401

Punjab province was found to have the second highest number of cases in Pakistan with 92.94% recovery rate and 2.29% mortality rate. Fig 3 shows the overall variation of Covid-19 cases in Pakistan region wise. The decreasing trend of Punjab province is more visible as compared to other regions.
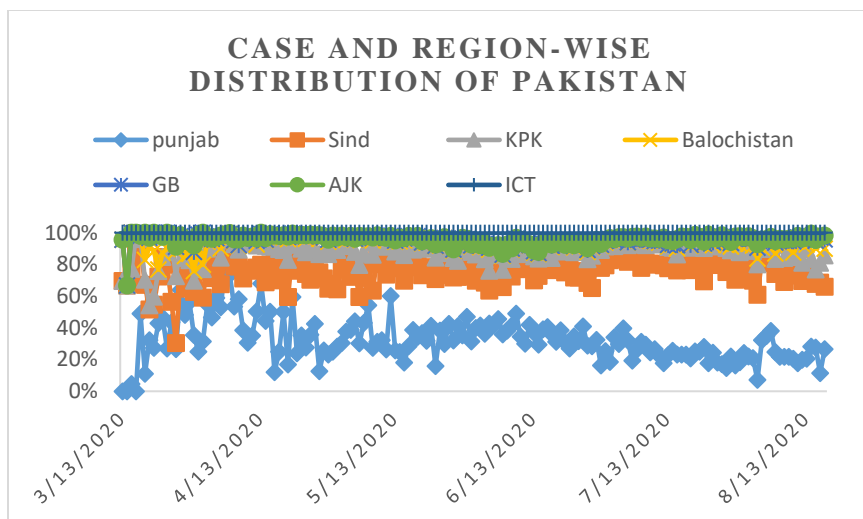

Figure 3. Region wise comparison of COVID-19 cases in Pakistan

Figure 3 shows the comparison between all administrative regions of Pakistan and it shows that the number of active cases in Punjab is decreasing more rapidly as compared to other regions.

Table 3 explains the variance and covariance for cases in all regions of Pakistan which shows that the patients travel from one region to another, frequently. Punjab and Sindh have the maximum number of patients which means that Covid-19 patients have greater interaction with the healthy population of these two regions. GB and AJK have relatively fewer cases of COVID-19 because of limited interaction with other regions and restricted movement of their people.

The correlation coefficients of these regions are shown in Table 4 which clearly explains the relationship between different regions of Pakistan. Punjab and Sindh have a more significant and positive relationship with each other and they impact the rest of the country significantly. The weakest relationship is between AJK and GB and these regions do not impact the rest of the country significantly.

Table 3
Covariance of Different Regions of Pakistan

	Punjab	*Sindh*	*KPK*	*Balochistan*	*GB*	*AJK*	*ICT*
Punjab	414234.9507						
Sindh	388733.5139	544071.8					
KPK	111673.9304	124768.6	40170.7206				
Balochistan	43434.22613	37534	11941.20209	7998.196			
GB	3070.426414	3361.211	1010.011497	406.9044	152.8061		
AJK	5858.699607	9153.178	1993.727247	432.7537	73.57847	273.0629	
ICT	78087.20337	78418.9	24136.40454	9230.219	782.9313	1172.361	19750.29

Table 4
Correlation Coefficient of Different Regions of Pakistan

	Punjab	*Sindh*	*KPK*	*Balochistan*	*GB*	*AJK*	*ICT*
Punjab	1						
Sindh	0.81856135	1					
KPK	0.876326108	0.854602	1				
Balochistan	0.753558768	0.5684	0.673895096	1			
GB	0.383420947	0.366368	0.410263298	0.365426	1		
AJK	0.550677449	0.750952	0.60956639	0.292528	0.357989	1	
ICT	0.863129177	0.756591	0.86781612	0.733733	0.447963	0.504892	1

4.1. COVID-19 in Pakistan

Overall, the cases of COVID-19 are increasingly decreasing in Pakistan. Pakistan is performing better because of the decreasing trend in the daily number of cases of the novel coronavirus, although in the long run, the polynomial line in Fig 4 shows the curve moving downwards.
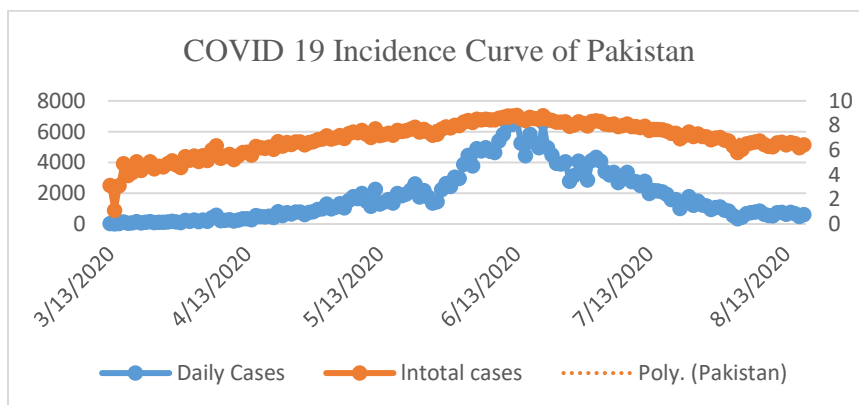

Figure 4. COVID-19 incidence curve of Pakistan

4.2. Punjab

Current COVID-19 data shows that the situation of Punjab is critical. The following Figure 5 shows that the number of daily cases of COVID-19 in the province is increasing. However, the situation of COVID-19 would be under control in near future as in the long run the polynomial line shows the curve moving downwards. This is a good sign since it predicts that the province with the largest population will have a decreasing number of COVID-19 cases in the coming months. The polynomial model in Fig 5 shows that cases are increasing on a daily basis but the curve is bending.

Punjab has a greater ability to control and overcome the pandemic situation. Data shows that total cases in the region are 95,611 which is 32.99% of total cases in Pakistan. It is also the second highest number of cases with 2.26% death rate and 92.94% recovery rate (MNHS, 2020). The recovery rate from COVID-19 in Punjab is the second highest in the country which forecasts considerable improvement in the current situation regarding COVID-19 in the region.
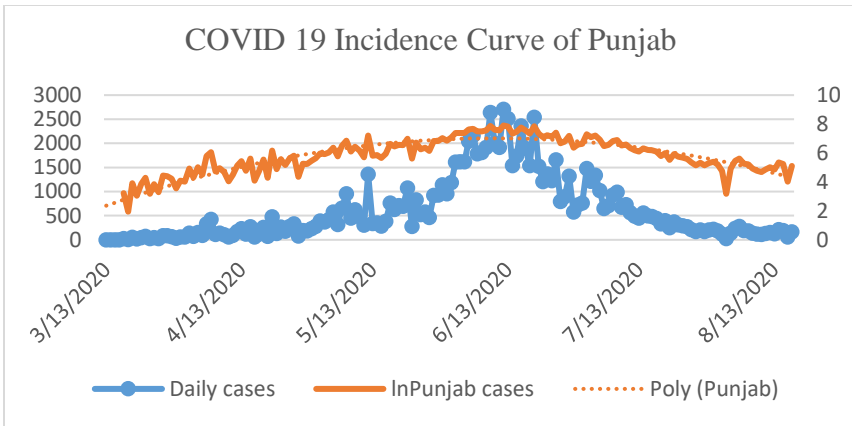
Figure 5. COVID-19 incidence curve of Punjab

4.3. Sindh

The second largest province of Pakistan also depicts an increasing trend of cases of COVID-19. The polynomial line shows that cases are on a threshold and are expected to decrease as well. The polynomial curve in Fig 6 shows the decreasing trend of the daily cases in the long-run.
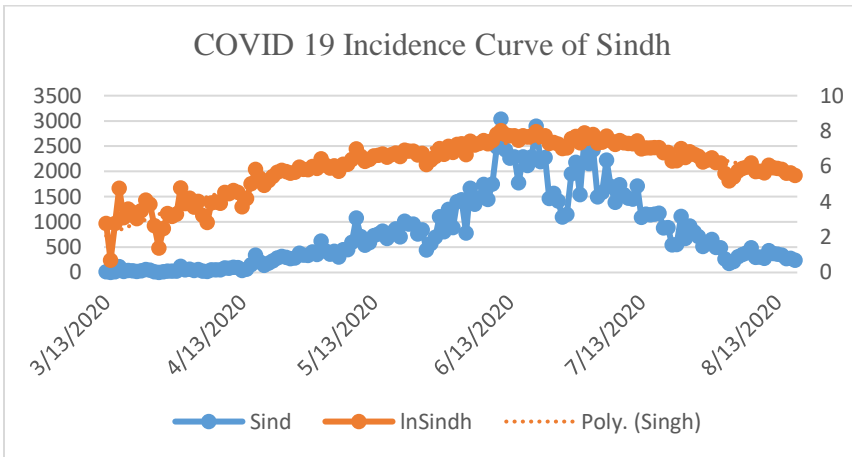

Figure 6. COVID-19 incidence curve of Sindh

The government of Sindh is also working hard to control the virus spread using complete lockdown but the situation is worsening due to more cases on a daily basis. The total number of cases in the province is 126,425, which is 37.66% of the total cases in Pakistan, with 1.84% mortality rate and 94.8% recovery rate (MNHS, 2020).

The results show the highest percentage of COVID-19 cases, the fastest recovery rate, and the lowest mortality rate among the various regions of Pakistan.

4.4. Balochistan

Balochistan is also affected by COVID-19 with instant fluctuations in its cases and a downward trend. The polynomial curve in Fig 7 shows the decreasing trend of cases on a daily basis.
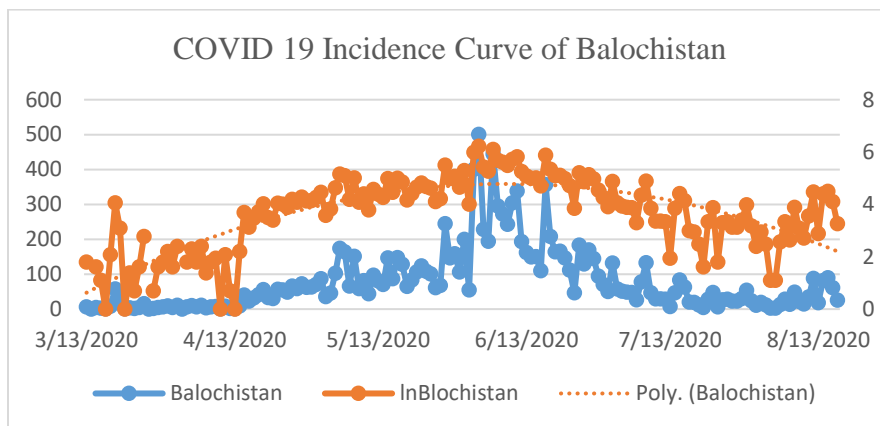

Figure 7. COVID-19 incidence curve of Balochistan

The total number of cases in the region is 12,321, which is 4.25% of the total cases in Pakistan, with 1.12% mortality rate and 90.52% recovery rate (MNHS, 2020). The results show that the government of Balochistan should focus on improving the quality of administrative work to improve the recovery rate and to lower the mortality rate.

4.5. Khyber Pakhtunkhwa

Khyber Pakhtunkhwa fares well in controlling the COVID-19. The results show that cases are reducing on a daily basis and the polynomial trend in Fig 8 shows the curve moving downwards.

The government of KPK is also working hard to overcome the pandemic situation. The total number of cases in the region is 35,337, which is 20.02% of the total cases in Pakistan, with 3.51% mortality rate and 92.03% recovery rate (MNHS, 2020). The results show that the highest percentage of deaths due to COVID-19 is in KPK.
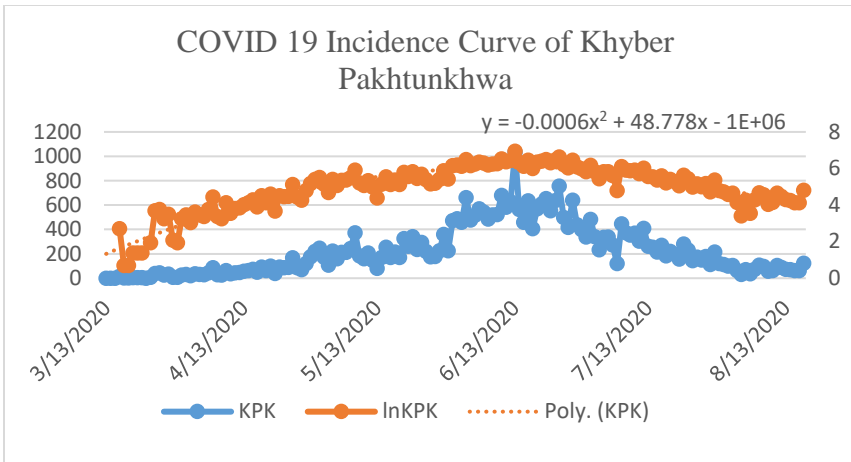
The chart title reads "COVID 19 Incidence Curve of Khyber Pakhtunkhwa" with the equation $y = -0.0006x^2 + 48.778x - 1E+06$

Figure 8. COVID-19 incidence curve of Khyber Pakhtunkhwa

4.6. Gilgit-Baltistan

Fortunately, Gilgit-Baltistan is less affected in terms of the number of COVID-19 cases in Pakistan. The total number of cases in the region is 2,538, which is 0.98% of the total cases in Pakistan, with 2.4% mortality rate and 85.58% recovery rate. It is the lowest recovery rate among all the regions of Pakistan.
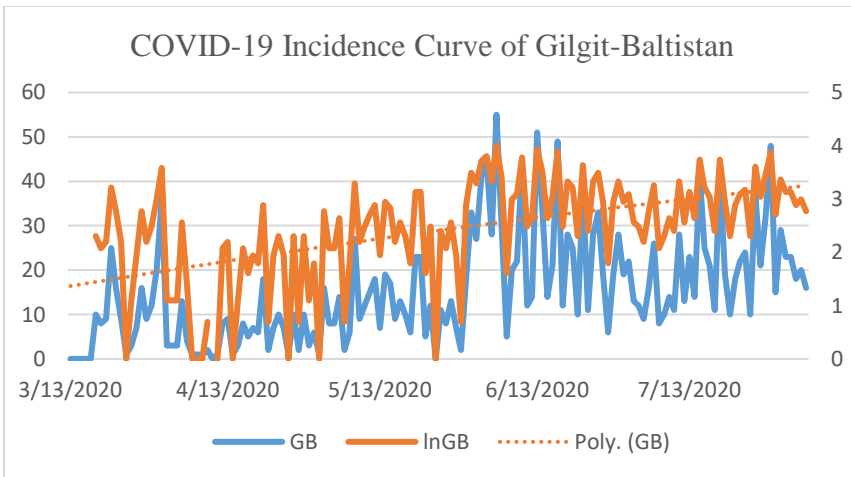

Figure 9. COVID-19 incidence curve of Gilgit-Baltistan

The results show the lowest percentage of recovery of COVID-19 patients in Gilgit-Baltistan (MNHS, 2020). The polynomial curve is slowly moving downwards as shown in Fig 9.

4.7. Azad Jammu and Kashmir

Azad Jammu and Kashmir also show an increasing number of daily cases of COVID-19. However, the polynomial curve in Fig 10 shows a declining trend in the long-run, which shows that the number of cases may decline in the near future.
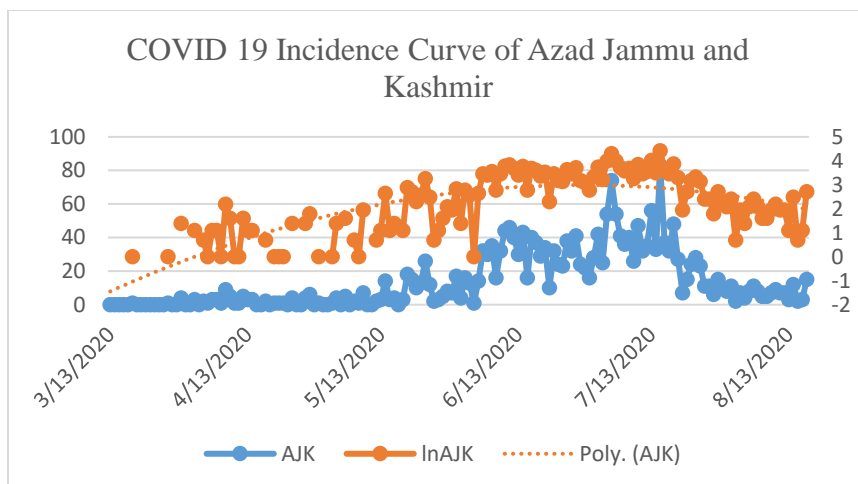

Figure 10. COVID-19 incidence curve of Azad Jammu and Kashmir

AJK has strived a lot to overcome the pandemic situation. The total number of cases in the region is 2,199, which is 0.76% of the total cases in Pakistan, with 2.77% mortality rate and 91.04% recovery rate (MNHS, 2020). The results show a good percentage of recovery and a low mortality rate during the last six months in the AJK region.

4.8. Islamabad

The increasing number of daily cases of COVID-19 in the capital of Pakistan is an alarming sign. The polynomial curve shows upward recoveries as compared to others a which depicts an increasing number of cases in June and July but the trend is moving downwards in the long-run as shown in Fig 11.

The total number of cases in the capital is 15,401, which is 5.31% of the total cases in Pakistan, with 1.14% mortality rate and 87.20% recovery rate (MNHS, 2020). The results show a slow recovery as well as a low mortality rate in comparison with other regions of Pakistan during the last six months. The same is

concluded by (Asghar et al., 2020) regarding the implementation of smart lockdown in Pakistan.
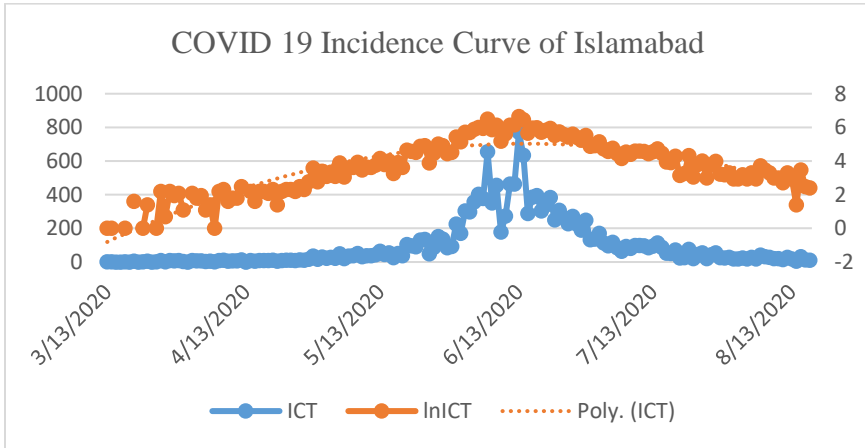

Figure 11. COVID-19 incidence curve of Islamabad

Table 5
Polynomial Models of Different Regions of Pakistan

Dependent Variable	Intercept	Slope of X	Slope of X^2
Punjab	-1000000	51.749	-0.0006
Sindh	-1000000	48.31	-0.0005
Balochistan	-1000000	47.414	-0.0005
KPK	-1000000	48.778	-0.0006
GB	-64134	2.9042	-0.00003
AJK	-761492	34.606	-0.0004
ICT	-1000000	58.438	-0.0007

Table 5 shows the polynomial models of all the regions of Pakistan. It shows the non-linear effect of the novel coronavirus cases in these regions. The results reveal the decreasing number of patients during the first wave of Covid-19. All the slops of variable (X) for Punjab, Sindh, Balochistan, KPK, GB, AJK, and ICT are positive which shows the direct and increasing effect of COVID-19 cases in the various regions of Pakistan. All the above slops of X^2 are in the negative, so the COVID-19 cases are decreasing in these regions since August 2020 but a second wave is expected (Solis et al., 2020).

5. Conclusion and Discussion

SARS-CoV-2 is a new virus that is not easy to control in most cases. The current medical facilities are not enough to deal with it all over the world, as in Italy where all medical resources are already over-utilized and the next patient has to wait for the death or the recovery of an existing patient. The situation of COVID-19 in Pakistan is also critical due to the high number of daily cases. Evidence based approaches are used to evaluate short-term and long-term effects due to the daily increasing number of cases of COVID-19 in Pakistan. The results showed that Sindh did well in implementing smart lockdown with more recoveries as compared to other administrative regions of Pakistan. The result of polynomial models shows the numbers of COVID-19 cases are increasing rapidly in the short-run in Punjab, Sindh, and KPK, which are the most populous regions of Pakistan, and they will adversely impact COVID-19 cases in other administrative regions. So, without following proper lockdown along with other preventive strategies discussed in this paper, there will a chance of an uncontrollable increase of COVID-19 cases in Pakistan. It was already observed in the United States (Solis et al., 2020) and France (Roux, Massonnaud, & Crepey, 2020). Most countries followed the complete lockdown strategy, although it is not a wise strategy for developing countries where per-capita income is much less than developed countries and the number of persons living below the poverty line is considerably more. Complete lockdown will adversely affect the economy of these countries and will increase the difficulties for the poor, whereas smart lockdown is effective without disturbing the economy. So, an intelligent-smart approach to handle the COVID-19 situation is an effective, desirable, and long-term solution which emphasizes educating people, maintaining social distancing, relief package, and business SOPs as well as a smart lockdown. In the initial stage, there may be more positive cases, although later it will effectively reduce the number of active cases as well as the mortality rate. COVID-19 situation in Pakistan is under control now although there is a risk of its second wave as second and third waves of COVID-19 have already occurred in the United States (Solis et al., 2020). However, it can be avoided by following the proposed approach before time.

This approach is also effective in reducing psychological stress and fear due to the COVID-19 situation.

References

Abdullah, M. S., Ul Islam, S., Mehmud, T., & Qazi, S. (2020). The social impacts of lock down in Pakistan in the COVID019 scenario. *Academy of Social Science Journals, 5*(7), 1698-1703.

Ahmad, S. O. (2017). *Cracking E-commerce 2.0: Whitepaper on taking 500,000 merchants online in Pakistan*. Islamabad, Pakistan: Planet N & Karandaaz Pakistan.

Ai, T., Yang, Z., Hou, H., Zhan, C., Chen, C., Lv, W., . . . Xia, L. (2020). Correlation of Chest CT and RT-PCR testing in coronavirus disease 2019 (COVID-19) in China: A report of 1014 Cases. *Radiology, 296*(2), 32-40.

Asghar, N., Batool, M., Farooq, F., & Rehman, H. U. (2020). Covid-19 Pandemic and Pakistan Economy: A Preliminary Survey. *Review of Economics and Development Studies, 6*(2), 447-559.

Banerjee, D. (2020). The COVID-19 outbreak: Crucial role the psychiatrists can play. *Asian Journal of Psychiatry, 50*. doi: 10.1016/j.ajp.2020.102014

Barrech, D. M. (2020, April 6). Controversy of lockdown and social-distancing in Pakistan. *Modern Diplomacy*. Retrieved from https://moderndiplomacy.eu/2020/04/26/controversy-of-lockdown-and-social-distancing-in-pakistan/

Becher, T., & Frerichs, I. (2020). Mortality in COVID-19 is not merely a question of resource availability. *The Lancet Respiratory Medicine, 8*(9), 832-833.

Behncke, H. (2001). Optimal control of deterministic epidemics. *Optimal Control Applications and Methods, 269*(6), 269-285.

Centre for Disease Control and Prevention (CDC). (2020a). *Cleaning and disinfection for households*. Retrieved from https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/cleaning-disinfection.html

Centre for Disease Control and Prevention (CDC). (2020b). *Situation summary*. Retrieved from https://www.cdc.gov/coronavirus/2019-nCoV/summary.html

Chan, J. F.-W., Yuan, S., Kok, K.-H., To, K. K.-W., Chu, H., & Yang, J., … Yeun, K.-Y. (2020). A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: A study of a family cluster. *The Lancet. 395*(10223), 469-470.

Chohan, U. W. (2020). *Forecasting the economic impact of coronavirus on developing countries: Case of Pakistan* (CASS Working papers on Economics & National Affairs, Working Paper No. EC016UC/2020). Retrieved from SSRN website: file:///C:/Users/20904/Downloads/SSRN-id3563616.pdf

Christie, L. (2014, June 5). *America's homes are bigger than ever*. Retrieved from https://money.cnn.com/2014/06/04/real_estate /american-home-size/

Coronavirus in Pakistan: Pakistan sees COVID-19 decline after enforcing smart lockdown. (2020, July 23). *Times of India*. Retrieved from https://timesofindia.indiatimes.com/world /pakistan/pakistanseescovid19declineafterenforcingsmartlockd own/articleshow/77121055.cms

Dar, M. S., Ahmed, S., & Raziq, A. (2017). Small and medium-size enterprises in Pakistan: Definition and critical issues. *Pakistan Business Review, 19*(1), 46-70.

Dua, Z., Javana, E., Nugenta, C., Cowlingb, B. J., & Meyers, L. A. (2020). Using the COVID-19 to influenza ratio to estimate early pandemic spread in Wuhan, China and Seattle, US. *E-Clinical Medicine, 26*, 1-8.

Farooq, F., Khan, J., Khan, M. S. G. (2020). Effect of Lockdown on the spread of COVID-19 in Pakistan. *arXiv preprint*. Retrieved from https://arxiv.org/abs/2005.09422

Fliegauf, E., & Ayres, A. (2020, April 30). *Coronavirus in South Asia April 30, 2020: India, Pakistan, and Bangladesh begin easing restrictions*. Retrieved from https://www.cfr.org/blog /coronavirus-southasiaapril302020indiapakistanandbangladesh- begin-easing-restrictions

Greenstone, M., & Nigam, V. (2020). *Does social distancing matter?* (University of Chicago, Becker Friedman Institute for

Economics Working Paper No. 2020-26). Retrieved from SSRN website: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3561244

Inoue, H., & Todo, Y. (2020). The propagation of the economic impact through supply chains: The case of a mega-city lockdown against the spread of COVID-19. *PLOS ONE, 15*(9). doi: 10.1371/journal.pone.0239251

Javed, H. (2020, April 19). Pakistan economic crisis amid the Covid-19. *Daily Times*. Retrieved from https://dailytimes.com.pk/598211/pakistan-economic-crisis-amid-the-covid-19/

Kissler, S., Tedijanto, C., Lipsitch, M., & Grad, Y. (2020). Social distancing strategies for curbing the COVID-19 epidemic. *medRxiv: The preprint server for Health Sciences*. doi: 10.1101/2020.03.22.20041079

Luther, C. (2018, July 1). *The average American monthly salary*. Retrieved from https://work.chron.com/average-american-monthly-salary-8614.html

Mahmood, A. (2020, April 16). Ease in lockdown' sets in confusion in Punjab. *Daily Dawn*. Retrieved from https://www.dawn.com/news/1549562

Masuda, N., & Holme, P. (2013). Predicting and controlling infectious disease epidemics using temporal networks. *F1000prime Reports, 5*,(6). doi: 10.12703/P5-6

Ministry of Finance. (2016). *Pakistan economic survey 2015-16*. Retrieved from http://www.finance.gov.pk/survey_1516.html

Ministry of Finance. (2019). *Pakistan economic survey 2018-19*. Retrieved from http://www.finance.gov.pk/survey_1819.html

Ministry of National Health Services (MNHS). (2020, August 17). *COVID-19 Health advisory platform by ministry of national health services regulations and coordination*. Retrieved from http://covid.gov.pk

Mukhtar, S. (2020). Mental health and psychosocial aspects of coronavirus outbreak in Pakistan: Psychological intervention for public mental health crisis. *Asian Journal of Psychiatry*, *51*. doi: 10.1016/j.ajp.2020.102069

Nafees, M., & Khan, F. (2020). Pakistan's response to COVID-19 pandemic and efficacy of quarantine and partial lockdown: Facts, hopes and expectations. *Electronic Journal of General Medicine, 17*(6), 1-4.

Nishtar, S. (2020, April 9). Distribution of coronavirus relief funds under Ehsaas Programme to begin from today. *GEO TV Network*. Retrieved from https://www.geo.tv/latest/281820-distribution-of-coronavirus-relieffundsunderehsaasprogramme-to-begin-from-today

Otim-Nape, G. W., Bua, A., & Baguma, Y. (1994). Accelerating the transfer of improved production technologies: Controlling African cassava mosaic virus disease epidemics in Uganda. *African Crop Science Journal, 2*(4), 479-495.

Pakistan's 30 cities under smart lockdown to control COVID-19 spread: PM Office. (2020, July 9). Retrieved from http://www.xinhuanet.com/english/202007/09/c_139198113.htm

Peng,T., Liu, X., Ni, H., Cui, Z., Du, L. (2020). City lockdown and nationwide intensive community screening are effective in controlling the COVID-19 epidemic: Analysis based on a modified SIR model. *PLoS ONE, 15*(8), doi: 10.1371/journal.pone.0238411

Poloni, T. E., Carlos, A. F., Cairati, M., Cutaia, C., Medici, V., Marelli, E., . . . Gauita, A. (2020). Prevalence and prognostic value of deliriumas the initial presentation of COVID-19 in the elderly with dementia: An Italian retrospective study. *E-Clinical Medicine, 26*,k. doi: 10.1016/j.eclinm.2020.100490

Raja, H. Z., Saleem, M. N., Saleem, T., Rashid, H., Ehsan, S., Hakeem, S., & Hanif, A. (2020, July). Perceived stress levels in Pakistani dental students during COVID-19 lockdown. *European Journal of Dental and Oral Health, 1*(4). doi: 10.24018/ejdent.2020.1.4.14

Rana, S. (2017, August 26). Census 2017: Family size shrinks. *Daily Tribune*. Retrieved from https://tribune.com.pk/story/1491353/census-2017-family-size-shrinks/

Raza, D., Ehsan, M., Khan, S. U., Raza, A., Saeed, U., Akmal, F., & Aziz, H. (2020). Dire situation of covid-19 in Pakistan and its impact on aerosol optical depth: A case study. *BUJES, 5*(1), 1-7.

Ren, S. Y., Gao, R. D., & Chen, Y. L. (2020). Fear can be more harmful than the severe acute respiratory syndrome coronavirus 2 in controlling the corona virus disease 2019 epidemic. *World journal of clinical cases*, *8*(4), 652.

Roberts, W. (2020, April 24). US Congress gives final approval on $484bn relief package. *Aljazeera TV*. Retrieved from https://www.aljazeera.com/news/2020/04/congressfinalapproval-500bn-relief-package-200423191131047.html

Roux, J., Massonnaud, C., & Crepey, P. (2020). COVID-19: One-month impact of the French lockdown on the epidemic. *medRxiv: The preprint server for Health Sciences*. doi: 10.1101/2020.04.22.20075705

Rukh, L., Khan, F., & Nafees, M. ( ). *A review of the possible economic impact of coronavirus on tourism industry of Pakistan*. doi: 10.13140/RG.2.2.29690.31682

Rukh, L., Nafees, M., Khan, F. (2020b). *Evaluation of forced-lockdown partial lockdown and smart-lockdown against COVID-19 hazard and related problems: An example from Pakistan*. Retrieved form Research Gate website: https://www.researchgate.net/profile/Nafees_Mohammad/publication/340940868_Evaluation_of_ForcedLockdown_Partial_Lockdown_and_Smart-Lockdown_against_COVID-19_Hazard_and_Related_Problems_An_Example_from_Pakistan/links/5ea6b12492851c1a90734cda/Evaluation-of-Forced-Lockdown Partial-Lockdown-and-Smart-Lockdown-against-COVID-19-Hazard-and-Related-Problems-An-Example-from-Pakistan.pdf

Salim, N., Chan, W. H., Mansor, S., Bazin, N. E., Amaran, S., Faudzi, A. A.,…& Shithil, S. M. (2020). COVID-19 epidemic in Malaysia: Impact of lock-down on infection dynamics. *medRxiv: The preprint server for Health Sciences*. doi: 10.1101/2020.04.08.20057463

Sardar, T., Nadim, S. S., Rana, S., & Chattopadhyay, J. (2020). Assessment of 21 days lockdown effect in some states and overall India: A predictive mathematical study on COVID-19 outbreak. *Chaos, Solitons & Fractals, 139*. doi: 10.1016/j.chaos.2020.110078

Siddiqui, S. (2020, March 22). COVID-19 lockdown to leave people jobless, businesses closed in Pakistan. *Daily Tribune*. Retrieved from https://tribune.com.pk/story/2181238/2-locked-down-leave-people-jobless-businesses-closed/

Solis, J., Franco-Paredes, C., Henao-Martínez, A. F., Krsak, M., & Zimmer, S. M. (2020). Structural vulnerability in the US revealed in three waves of COVID-19. *The American Journal of Tropical Medicine and Hygiene, 103*(1), 25-27.

Strzelecki, A. (2020). The second worldwide wave of interest in coronavirus since the COVID-19 outbreaks in South Korea, Italy and Iran: A google trends study. *Brain, Behavior and Immunity, 88,* 950-951.

Squalid Taftan quarantine camps present a sorry state of affairs. (2020, March 19). *Daily Dawn*. Retrieved from https://www.dawn.com/news/1542153

SMEs, markets want relaxation in lockdown for economic activities continuation. (2020, April 11). *The Nation*. Retrieved from https://nation.com.pk/11-Apr2020/smesmarketswantrelaxation-in-lockdown-for-economic-activities-continuation

Umoh, M. J., Nseobot, I. R., Hamid, Y., Elyassami, S., Effiong, A. I., Ette, U., & Soomro, M. A. (2020, April). COVID-19 city locked down: Implications on welfare in developing countries. *International Journal of Business Education and Management Studies (IJBEMS), 4*(1), 1-6.

Vega, D. I. (2020). Lockdown, one, two, none, or smart. Modeling containing COVID-19 infection. A conceptual mode. *Science of the Total Environment, 730*. doi: 10.1016/j.scitotenv.2020.138917

Wilder-Smith, A., & Freedman, D. O. (2020). Isolation, quarantine, social distancing and community containment: Pivotal role for

old-style public health measures in the novel coronavirus (2019-nCoV) outbreak. *Journal of Travel Medicine, 27*(2), 1-4.

World Bank. (2018). Population density (people per sq. km of land area). Retrieved from https://data.worldbank.org/indicator/EN.POP.DNST?view=chart

World Bank. (2020). Poverty headcount ratio at $1.90 a da*y*. Retrieved from https://data.worldbank.org/indicator/SI.POV.DDAY

World Health Organization (WHO). (2020, April 29). *Coronavirus disease (COVID-19) advice for the public.* Retrieved from https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public

Zhou, P., Yang, X.-L., Wang, X.-G., Hu, B., Zhang, L., Zhang, W., &… Si, H. R. (2020). A pneumonia outbreak associated with a new coronavirus of probable bat origin. *Nature, 579* (7798), 270-273.