Advances
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REVIEW ARTICLE

Forecasting Analysis of Covid-19 and Current Status of Public Health Management in Pakistan

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ABSTRACT
The global spread of 2019 novel coronavirus (COVID-19) infection from epicenter of Wuhan- china has also affected Pakistan. First 2 cases of COVID-19 were reported on 26th February 2020 in Pakistan. The numbers of cases reported were very low initially for few days. However, from 15th march 2020 the infection rate increased dramatically. Surprisingly the mortality rate between 15th march and 5th May 2020 remained very low, as compared to the rest of the world, especially USA. Based on incubation period of COVID-19 (normally from 2-14 days), mean of 5 days is approximately selected for onset of symptoms of any infected patients in this study. Also, the study is conducted on the basis of data available between 15th March and 5th May 2020. Moreover, R0 value (basic reproductive number) is further categorized into two cycles of infection. Daily Combined estimated number of patients in two cycles of infection and the total number of "daily reported confirm cases" are compared. Moreover our findings demonstrates the herd immunity to the 70% population in about 1300 days will result in deaths of nearly half a million people (0.28%) in the country based on "daily estimated number of actual cases" or 23 million deaths (2.33%) can occur, considering "the daily reported number of confirm cases" The margin of difference between the government reported daily confirm cases and "estimated daily actual cases" will determine the impact of counter health measures on this outbreak in Pakistan.
Keywords. Covid-19, Forecasting, Current Status, Public Health Management, Pakistan.

INTRODUCTION

A novel coronavirus (COVID-19) is a new mutated coronavirus that has not been previously identified. SARS-COV-1 has led to an outbreak of SARS (Severe acute respiratory syndrome) in china between the years 2002 and 2003 (Reference pls). However, SARS-coV-2 virus is known to be mutated from SARS-coV-1. The disease caused by SARS-COV-2 is named as "COVID-COV-19"(corona virus disease, discovered in 2019). This outbreak started in the month of December 2019, as an unknown cluster of respiratory illnesses first reported from Wuhan City, China. [1]

A tremendous amount of information is yet to be published about COVID-19. There are various different strains of Corona virus. The above-mentioned strain is a mutated type of one of Corona Viruses. This mutation has never been reported in known human history where humans are affected by Corona viruses. Spikes of corona virus have receptors on epithelial cells called Angiotensin converting receptors (ACE-2). [2] Mutation has resulted in increased adsorption of virus to epithelial cell thus making it more easily transmissible and in turn the susceptibility rate of individuals has increased. As this virus not only present in saliva, sputum, blood samples but significant viral load have been reported in stool, nasal secretion, and urine samples of infected patients as well. COVID-19 can contaminate the environment through multiple sources [3]. A recent study published in the New England journal of medicine, scientists reported sars-cov-2 which cause covid-19 disease, was detected in aerosols for up to three hours, up to four hours on copper, no longer than 24 hours on cardboard and up to three hours on plastics and stainless steel.[4]. These features of covid-19 increase the susceptibility of human and other species to enormous extent.

COVID-19 outbreak has caused an urgency to create a safe laboratory environment especially in a country like Pakistan with one of the highest population densities in the world and where the insufficient healthcare facilities is on the verge of causing severe consequences. The country has a negligible number of trained quarantine experts and no training program for the need of formulating institutional biosafety policies in order to reduce the incidence of serious infections like COVID-19.Majority of technicians conventionally handling CoVid-19 patients, are unaware of diversity of samples containing the virus which may lead to complicate patients management and environmental contamination. [5, 6]

Moreover, the limited capacity of Pakistan for testing every suspected individual might affect the accuracy of statistics of confirmed cases which results in less effective outcome despite of government's precise counter strategies, also it might cause the widespread of COV2 virus by the individuals that are not being tested [7]. The precise counter measurement for the control of viral transmission is not feasible without the comprehensive data on confirmed cases and rate of mortalities in affected areas.

COVID-19 OUTBREAK AND COUNTER HEALTH MEASUREMENTS STATUS OF PAKISTAN.

Studies from the developed countries indicate that community settings as compared to healthcare settings were more responsible for transmission of CoV-2, lack of biosafety level 3 in Pakistani healthcare settings can render these equally responsible for disease transmission. According to the recent Clinical Experiences, WHO has published information for healthcare setting dedicated for CoVid-19, classification of cases, diagnosis, handling of samples, disinfection procedures and treatment [8]. Ironically, we neither have the necessary infrastructure as described by experts in the CoVid-19 protocols nor do we have awareness about proper disposal of medical waste and disinfection of patient's belongings including clothes, bed sheets, towels, masks, isolation wards etc. As the virus survives for longer time in the items mentioned above, chances of spread of the infection via these items are always there. In Pakistan, more than 275 people live in a square km which is far more than China, USA, Italy and Iran. There is a lot of burden on a couple of healthcare facilities dealing not only with CoVid-19 but lots of other diseases as well. In this situation, it is most probable to expect hospital acquired CoVid-19 cases in near future [9].

With regard to Covid-19 outbreak compliance with internationally accepted biosafety level 3 and biosecurity guidelines had to be practiced to minimize the exposure of laboratory workers and outer environment. Although there are countable number of BSL3 labs in the country, samples handling is being carried in labs and healthcare units with no biosafety levels in place because of lack of training. Apart from that, there is no system for disposal of medical waste at the national or provincial level. In a city like Abbottabad there are very few incinerators for management of medical waste from several private hospitals and the laboratories. Every day, Excessive medical waste thus reach to the local landfill sites of the city [10, 10a]. It is a clear warning indicating towards widespread of Covid-19 virus in entire city through hospital and laboratory waste. It is to be noted here that the virus is thought to be infectious not only for humans but other animals and bird's species as well, (Considering the population of street dogs in Pakistan). Although it is yet to be determined experimentally or via observation, Insilco studies indicate that such a situation will most likely arise due to the potential of the virus to infect other animal cells. It can cause tremendous loss and endanger our survival in terms of health, education and economy.

IMPORTANCE OF ACCURATE STATISTICAL DATA IN COVID-19 PANDEMIC

For future predictions and meticulous implementation of interventions, statistical analysis of this pandemic is very important. The precise counter measurements cannot take place without the comprehensive data on confirmed cases and rate of mortalities in effected locations of a country. These features give indications to estimate the susceptibility of acquiring infections in different regions within a particular lapse of time. The true number of people infected with COVID-19 is not known to any country in the world yet. Similarly, due to limited capacity of testing in Pakistan, the statistics of infected individuals most probably indicates the high-risk groups. The number of confirmed cases per the number of tests also demonstrates the high risk-groups, stereotyped on the basis of symptoms. The difference in testing ratio to the confirmed cases in Pakistan is most probably due to those tested individuals who have lived in close proximity to the confirmed cases which includes either family members at home or healthcare individuals routinely being tested while performing testing in laboratories as well as nurses and doctors managing these patients at hospitals [11].

In Pakistan, individuals showing major symptoms like dyspnea are primarily tested for serological markers such as leukocytopenia and X-ray or Ultrasound indicating the lungs status. However, if the condition is still not critical, patients are either prescribed for placebo medications or treated for other suspected infections like pneumonia or Malaria for a few days. If the condition persists, the testing for COVID-19 is then taken into account eventually by health care professionals. Most common prescriptions

for such symptomatic patients are azithromycin in combination with Hydroxychloroquine [12]. Many individuals with COVID-19 infection, are reported to be treated around the world with these prescriptions [13, 14]. However, those patients unexpectedly if treated with these medications still might be carriers of SARS-COV2 and might play a significant role in SARS-COV2 prevalence in community. If these individuals are not been tested for COVID-19 due to limited capacity of a country for testing, it might affect the accuracy of statistics in a particular region which results in less effective outcome despite of governments precise counter health strategies. Furthermore, throughout the world, there are reports published about asymptomatic COVID-19 patients as well. So those individuals are not tested routinely and also play an important role in widespread of SARS-COV2 virus [15].

NEW MODEL OF ESTIMATING THE ACTUAL NUMBER OF CASES VS REPORTED NUMBER OF CONFIRMED CASES

We have established the course of this pandemic in Pakistan on the basis of data provided by the government of Pakistan [16]. The dates selected in this study are between 15th March 2020 and 5th May 2020. **(Covid-9 Appendix)**

Even though, the first 2 cases of Covid-19 were reported on 26thFebruary 2020, the data available for number of confirmed had discrepancies due to small availability of diagnostics and very low number of patients reported initially.

The goal of this model is to estimate the actual new number of cases in Pakistan per day. The reported numbers of cases are based on the number of tests conducted. So, the overall estimated actual numbers of infected cases are far higher than the number of confirmed cases according to this model of study.

As from recent publications it is now well established that the symptoms begin to appear approximately on or after 5th day of infection. Also, one individual potentially spreads infection into 2.5 - 3 individuals.(17) However, R0 (basic reproduction number) selected in this model for SARS-COV-2 is equal to 3,during first five days of infection.

Table.1. An Overview of Statistical Model (Chart 1)

R0=3 PRIMARY PATIENT(DAY5)	(REPORTED CASE)DAY 1 AT HOSPITAL
3 PATIENTS IN 1ST CYCLE OF INFECTION (DAY1)	ASYMPTOMATIC
3 PATIENTS AT HOSPITAL/ASYMPTOMATIC (DAY5)	SYMPTOMATIC(AT HOSPITAL) ASYMPTOMATIC(IN COMMUNITY)
9 PATIENTS IN SECOND CYCLE OF INFECTION (DAY1)	ASYMPTOMATIC
9 PATIENTS IN SECOND CYCLE OF INFECTION (DAY5)	SYMPTOMATIC(AT HOSPITAL) ASYMPTOMATIC(IN COMMUNITY)

On march 21st, 2020 the number of reported new cases were 144 in Pakistan while the actual new cases on that day were 189.The actual new cases from march 21st will show symptoms on the 5th day of acquiring infection, which is 25th March and the number appears to be three times higher, which is 432

patients. This is called the "first cycle of infection" **(R0-1).** However, the reported confirmed cases on 25th march are only 91. While there are 567 patients already in first cycle of infections which is the R0 of confirmed cases 5 days before and they will show symptoms on 25th March 2020 as well. So, these patients are also added to the previous patients of 25thmarch, that makes it to a total estimated number of cases of 999.The government figure is withdrawn from this number (illustrated in chart-2) in overall statistics and the difference is illustrated in percentage. Moreover these 432 patients might have potentially infected three times the total number of individual patients during their asymptomatic period of infection. Which is 1296 and these patients have shown symptoms on 29th March, which is 5 days from 25thmarch. The 9th march period of infection is called "The second cycle of infection" **(R0-2).** So, on 29th march reported number of confirm cases were 102 whereas an estimated actual number of cases on that day were 273 from first cycle of infection (25th March) and 1296 cases from second cycle of infection (also from 25th march). So, the estimated total number of cases on 29th March are 1569 which is the total of patients infected in two cycles of infection **(R0-1 and R0-2).** In accordance, this modeling of statistics the chart is forecasted.
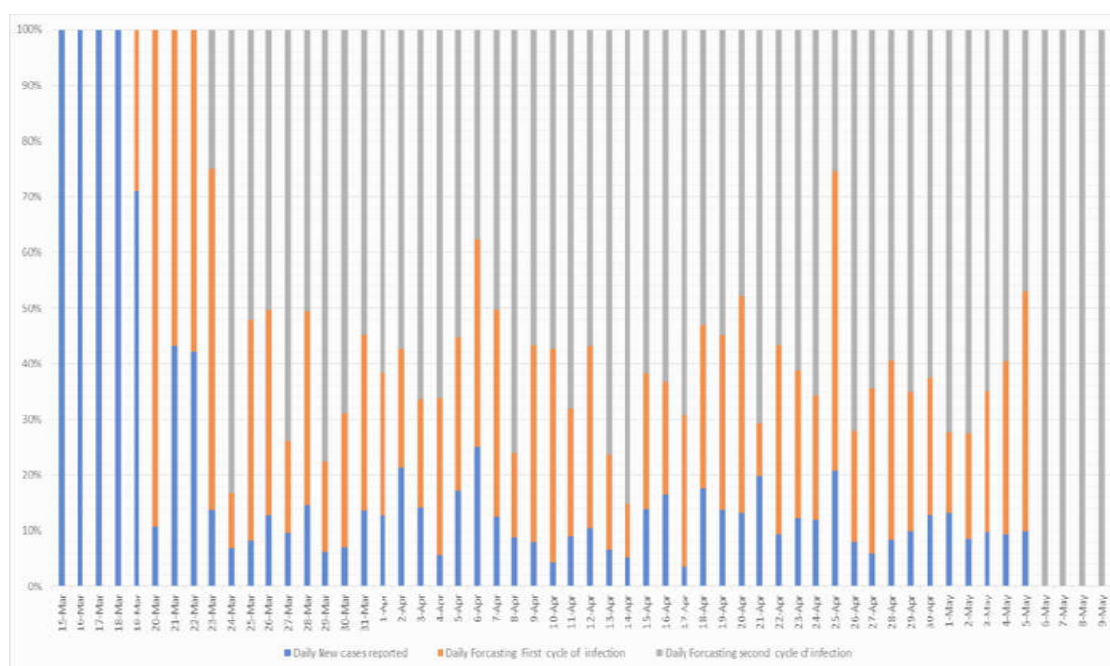

Fig 1. (Data in tables from Appendix1 covid-19) **chart 2 represents the difference in percentage of "daily reported cases" vs the daily estimated actual cases in two cycles of infection.**

Total R0 value of Daily estimated actual cases is calculated as below.
R0= R0-1 + R0-2 – R0
where
R0=Basic reproductive number of Daily reported cases
R0-1=Basic reproductive number of daily patients in first cycle of infection.
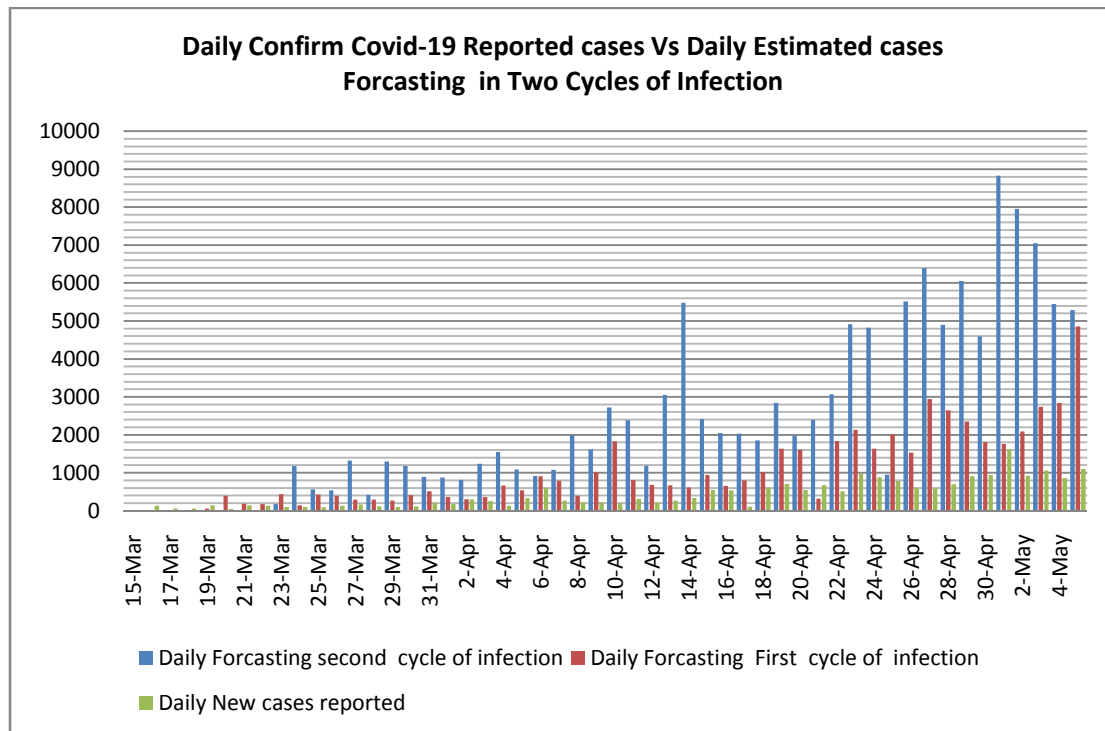R02=Basic reproduction number of daily patients in second cycle of infection.

Fig 2. The data table for chart 1 and 2 and 3 are in appendix 2(covid-19 Appendix) between 15th March and 5th April 2020

Overall estimate of actual number of cases in Pakistan between 15th March and 5th April is approximately 173823 patients, while the reported number of cases in Pakistan in this duration is 22016.
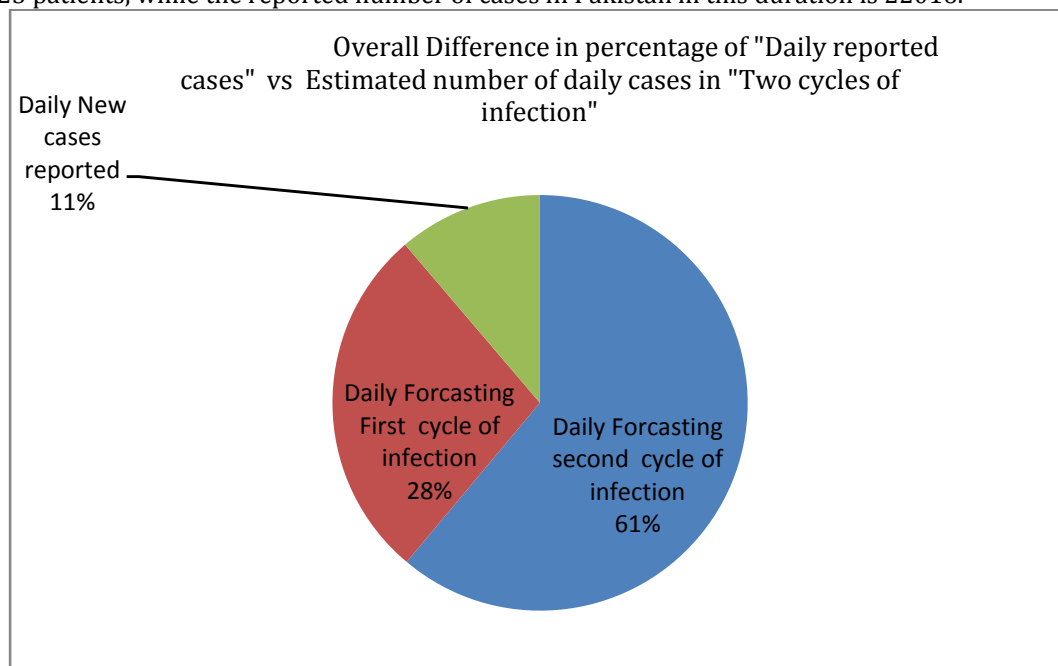

Fig 3. Predictive Analysis of COVID-19 Until 19 July 2020

According to this model of actual estimation, higher the number of cycles of infection, more rapid will be the spread of virus in population. However, these number of individual cycles of infections can be manipulated by the density level of population, immune response of individuals in community, environmental temperature, humidity level, frequency of interactions between population and the counter health measurements exercised by the government. Containment of virus is only possible when counter measurements are taken into account during the minimum number of these cycle of infection.

Higher the number of "cycles of infection", more challenging will be the establishment of counter health measurements for the government.
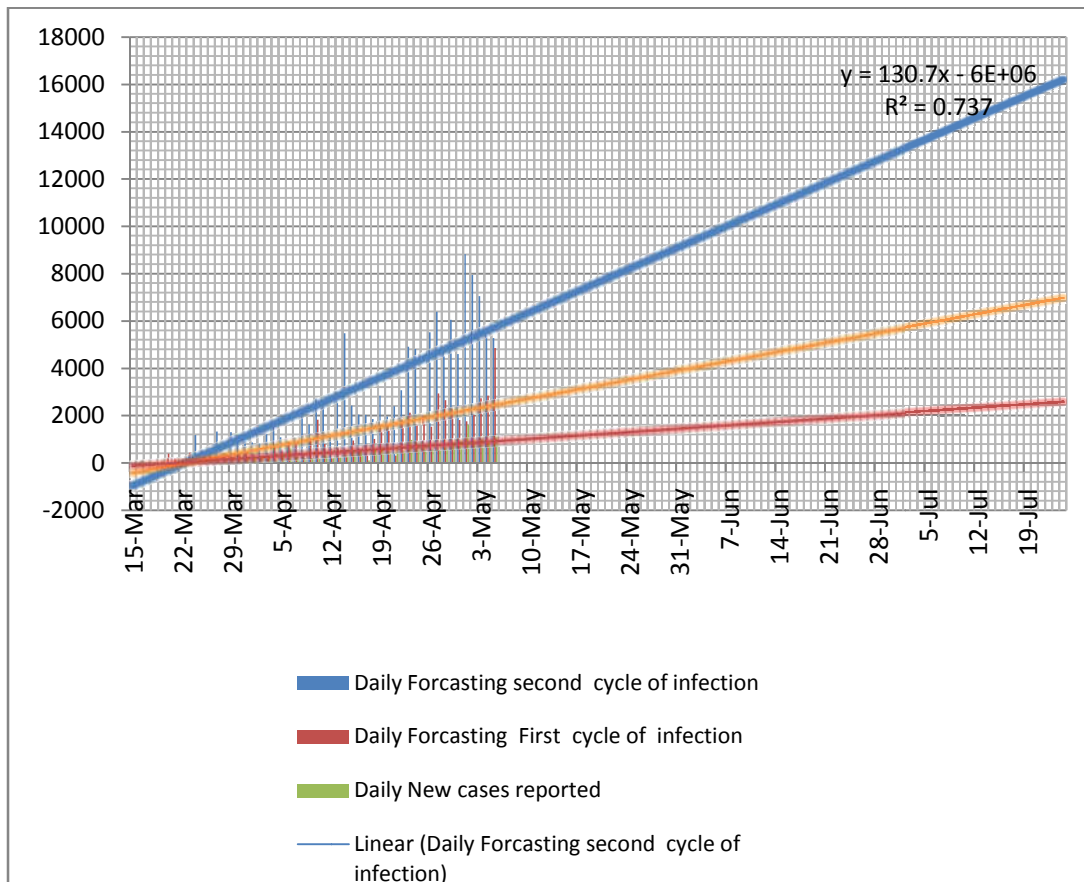

Fig 4. Forecasting Total Number of Cases in Two Cycles and Herd Immunity

On the basis of trend on Table1 the forecasted number of patients on 19th July 2020, will reach to the figure of around 1000 reported cases as well as 4700 from 1st cycle of infection and 15000 from second cycle of infection on daily basis. This will result in overall 19500 cases on a single day whereas 2000 will report, out of 19500. So the total cases on 19th july will be 17500 actual estimated number of patients.
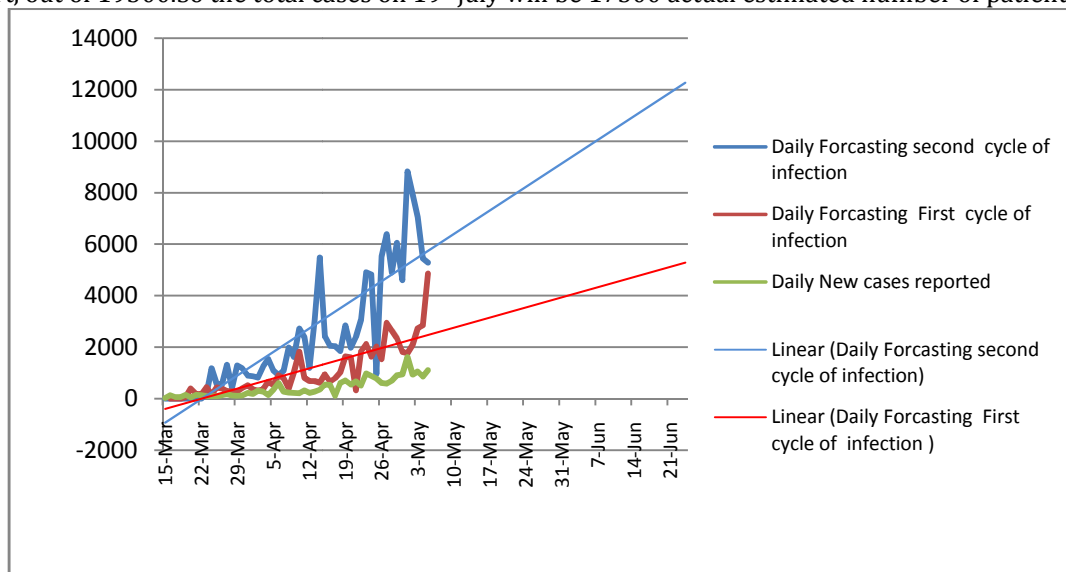

Fig 5. Daily reported Deaths

If the trend continues, until 21stJune 2020, daily number of cases from first cycle in Pakistan will be approximately 5000 and about 12500 will be from the second cycle of infection, which leads to a total of 17500 daily estimated cases. If the number remains constant (due to government counter-measures etc.) for 1300 days (around 3.5 years) from 21st June then the entire population of 220 million will acquire the herd immunity.

According to current mortality rate in Pakistan 2.15 percent (on 12th may 2020), the mortality rate will grow to 9.5 percent by the time entire population acquire herd immunity. In other words, for entire population to acquire herd immunity at 9.5 percent mortality in Pakistan, approximately 23,684,210 (more than 23 million) people will die in 3.5 years approximately.
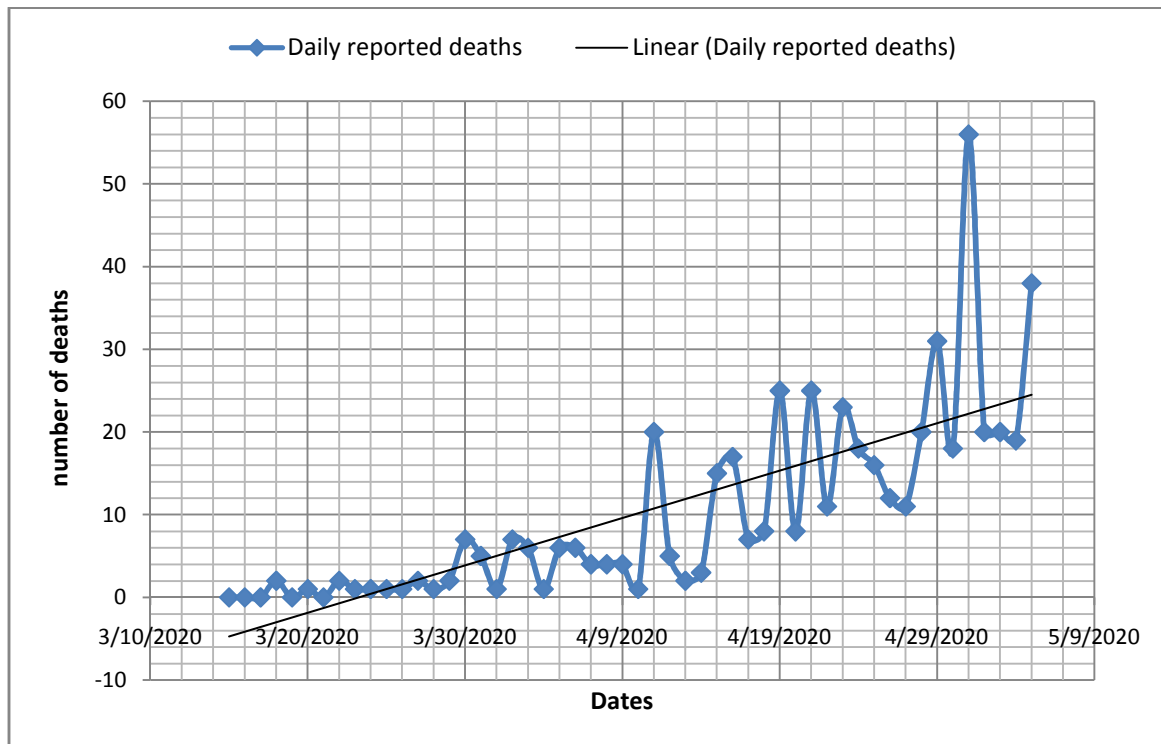
Illustrated in appendix2 sheet4.

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Fig 6. Ratio between total registered deaths of COVID-19 patients of specified months and total registered infected patients is calculated.

Ratio between total registered deaths of COVID-19 patients of specified months and total registered infected patients is calculated. The Moving Range (**MR**) charts, plot process variation, which are calculated from the ranges of multiple successive observations.

$$MR = \frac{\sum d}{\sum p} \times 100$$

Where as

  MR= Moving Range

$\sum$ d= Total registered deaths of corona patient of specified month

$\sum$ p= Total registered infected patients of corona virus of specified month

On the basis of total estimated cases on 5th May 2020 the mortality rate is 0.28%.

Calculated by Total estimated number of cases in 2 cycles of infection (179106) and total number of deaths (514) on 5th may 2020.If the number of infections continues with this mortality rate, then by the time entire population acquire herd immunity, the total number of deaths will be around half a million approximately
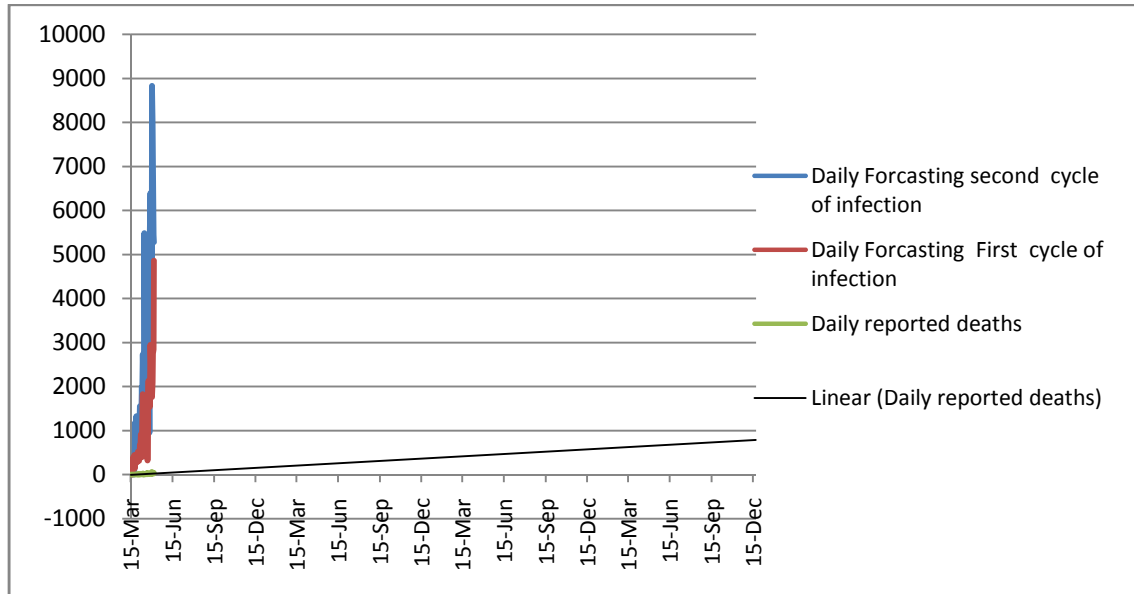
Fig 7. Forecasting Total number of deaths in 1300 days

Predictive analysis of mortality rate on the basis of total estimated number of cases in 3.5 years approximately. By the time the whole population of 2250 million acquires the herd immunity, daily mortalities will be roughly reach 900 individuals in last few months. On the basis of estimated number of actual daily infected cases and at 0.28% current mortality rate. A total of approximately 0.5 million deaths will occur, if the 70% population is infected in approximately coming 1300 days.

ROLE OF SCIENTISTS AND UNIVERSITIES OF PAKISTAN DURING COVID-19 PANDEMIC

Diagnosis of the patients in our healthcare settings is not according to the protocol which can in turn contribute to the spread of the virus in the healthy population. Nevertheless, the scientists from the faculty of health sciences from various universities in Pakistan possess the potential of establishment of state-of-the-art research center in emerging and re-merging infectious diseases with focused programs on management of outbreaks and epidemics. These scientists can minimize the risk of CoVid-19 and can also prepare for epidemics by analyzing the current situation on scientific grounds. This will help in encouragement of genuine research in the country and establishment of such mechanisms will help in determination of the productivity of local research not just by publication of papers but through practical contribution to society.

The concept of developing BSL3 laboratories resides within the principles of biosafety and biosecurity. We can achieve BSL3 protocols by implementing various degrees of laboratory control and containment, through laboratory design and access restrictions, professional expertise and training, use of containment equipment, and safe methods of managing infectious materials in a laboratory setting. An immediate up-gradation of existing BSL2 labs to BSL3 especially at government and private sector universities and arrangement for training of staff in BSL3 practices should be the government's first priority. Usually a well-trained staff of scientists from Universities is not only able to launch an immediate training programs to such labs but also channelize transportation of suspected samples to the designated labs only. Along with that, regulation of private laboratory set ups and strict warnings should be issued not to handle CoVid-19 cases and to install standard medical waste disposal system in order to avoid its transmission.

CONCLUSION

About 150 million Pakistanis will acquire immunity for COVID-19, to achieve a 70% threshold of herd immunity and in turn about half a million deaths might occur, based on estimated daily cases. It is therefore estimated that more than 23 million deaths can occur based on daily reported confirm cases in about 1300 days.

It is therefore important first to analyze the susceptibility dimensions of population to this infection. However, to unfold the pathological impact of SARS-cov2 on population, increased number of daily tests performed throughout the country will bring down the difference in "reported confirmed cases" and "estimated actual number of cases". Due to the minimal difference between actual cases and reported

cases, the government will ultimately be able to establish more precise counter health measurements including selective lockdown in the country rather than partial lockdown in the entire country. This will also minimize the socio-economic disruption caused by the COVID-19 pandemic. However, according to the overall studies published since the outbreak of Covid-19, world scientists are optimistic about the eradication of SARS-cov2 through the vaccine rather than herd immunity.

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