Signal-driven Covid-19 Management Strategy for Pakistan

By Rashid Langrial

Abstract

This paper explores using representative testing as the basis for a decentralized response to contain COVID-19 on the logic that homogenous corrective action (i.e., a nation-wide lockdown) is not a rational long-term response to address the uneven disease incidence that occurs as a consequence of heterogeneity in space and human behaviour.

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Executive Summary

At the tail end of December 2019, China reported a cluster of odd, pneumonia related deaths to the World Health Organization. Less than 3 months later, the COVID-19 disease was declared a pandemic. What happened between the identification of an apparently isolated cluster of disease in Wuhan, and infections in over 1.5 million people with approximately 110,000 deaths recorded around the world, was as simple, as it was complex; life had continued as usual.

Not only is this pandemic asserting an unprecedented strain on public health systems, it has now effectively forced life as we know it to stand still. Lockdowns, an almost complete suspension of all human activity, were identified as a first line of defense. Though apparently useful, given the immediate suppression of spread that lockdowns provide, they are equally tricky. There are multiple concerns that need to be addressed ranging from the devastating economic impact that a lockdown might have on a micro and macro level, to the false sense of security, and success, against the virus that a lockdown might give to a population in peril.

In order to ensure that a lockdown remains effective, it has to be administered keeping in mind two distinct purposes. First, ensuring that rigorous testing allows for identification of disease clusters to isolate and treat those already infected. Second, ensuring that a semblance of normalcy may be injected back into a society that seems shaken to its core. This normalcy comes in the shape of unlearning what we know, adapting to our circumstances, and re-learning what normal entails. Throughout, there has to be a constant reminder that the lockdown is not the end; it is merely a means to a world where we can learn to live with COVID-19.And that too, till such time that nature runs its course and eliminates the virus itself or scientists find a way to make and administer a vaccine to inoculate what is left of the 7.8 billion people of the world.

The proposal at hand attempts an effective management of COVID-19 keeping in view these two goals; running an effective testing campaign to cover as many people as possible, given resource constraints. And, designing and implementing lockdowns to ensure that they serve as an enabler, instead of an obvious obstruction to human life.

For testing, the proposal looks at the option of pooled testing; a tool currently being employed successfully by Germany. The main aim of pooled testing is to cut down the cost of testing per-person by taking 10 samples at once, and ensure that maximum coverage can be wrung out of limited testing capacity. For a country like Pakistan, already short on capital to invest in strengthening testing capacity, pooled testing can be a game changer.

In terms of intelligent lockdown design, the proposal identifies four distinct states of lockdown ranging from a skeletal lockdown, that only focuses on big restrictions, to a full-blown lockdown with complete cessation of even the smallest movements. The proposal describes a spectrum of the quality of life that each state of lockdown might provide, and explains how to use data gleaned from mass testing to ensure informed lockdown application so that areas where testing would show higher virus presence may be sealed with a full-blown lockdown, while areas with isolated pockets of the virus may employ an internally open, externally closed variation of the lockdown.

Finally, the proposal also identifies how the proposed adaptive triggering of various states of lockdown might help in slowing or stabilizing the economic collapse that a full-blown lockdown might have brought about on its own.

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BOS	Bureau of Statistics
COVID-19	Corona Virus Disease, 2019
GDP	Gross Domestic Product
GIS	Geographic Information System
GPS	Global Positioning System
NLR	National Lockdown Reserve
PCR	Polymerase Chain Reaction
PIDE	Pakistan Institute of Development Economics
NTRC	National Transport Research Centre
SARS-CoV-2	Severe Acute Respiratory Syndrome Corona Virus 2
WHO	World Health Organization

I. Background

An Unequal battle

Since the onset of COVID-19, the world has generally fumbled and faltered. And though there are some much-admired examples like China and some other South East Asian countries, the jury is still out on this issue. We also do not know what will happen during the second surge in East Asia; nor is the European record enviable, except perhaps the Germans.

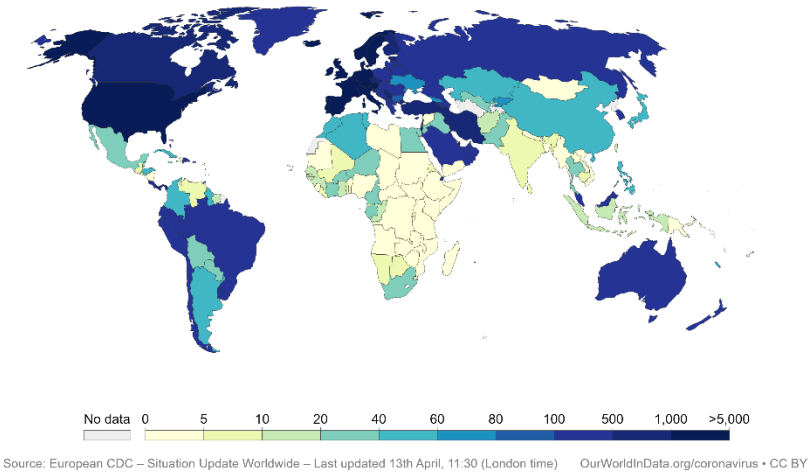

Figure 1: Confirmed COVID-19 cases per million, as of 13th April, 2020

What we are seeing in this modern world, despite medicine that has developed so much, is that the world has been collectively taken aback; there is almost a mass unnerving of sorts that has limited our ability to act rationally. We have laid off our wits, that ancient ally of sapiens in times of adversity.

Japan, initially, had a more passive reaction. With a different society, a different social ethic to live by, and a different social construct to live in, they adopted a business-as-usual approach. Now, however, they have realized that business-as-usual is not possible.

Britain had a certain hubris about their uniquely scientific approach; they thought that herd immunity would eventually save them. But they too had to change gears once they realized the folly of not doing anything and accepting mechanically the inevitability of certain percentage mortality rate.

Similarly, the Trumpian attitude in the US, touting invincibility, displaying a wild-west macho attitude towards the challenge of the pandemic, has failed the people of USA. They too, now, have gone the path of the lockdown. Unfortunately, COVID-19 does not respect Japanese exceptionalism or the English sense of uniqueness.

This mass unnerving largely comes from the absence of information. We do not know much about this Coronavirus. Moreover, the exponential speed of spread of this virus has also contributed to public alarm. The R_0, the reproductive rate, to be understood as how many infections one single infected individual will cause, has been as high as 27 in some cases. In one case, an individual has even been responsible for thousands of infections.

This exponential spread unnerves most leaders, not only at the national level but also at the level of global health policy professionals such as WHO experts.

The key is to understand how to deal with this lack of information.

Flight or fight; the nature of human response

When human beings confront a previously unknown threat, psychologists tell us they go into a "fight mode or flight" mode. In flight mode, one accepts inevitable defeat and waits for nature to offer options such as herd immunity. In fight mode, on the other hand, one takes the challenge as an affront to the ego and attacks. One example of the fight mode in this case is a full curfew-style lockdown in the entire country backed up by either capital punishment or institution of 'shoot-to-kill orders' as has been done in the Philippines.

In short, as an emergency response, lockdown might be a great strategy, even vital. However, this strategy cannot be sustained over a longer period of time.

II Understanding the Beast

Single-stage game vs Multi-Stage game

The problem with battling the SARS-CoV-2 (the virus that causes the COVID-19 disease), is hidden, perhaps, in its novel nature. A lockdown would be completely effective only in a single-stage game: COVID-19 is a multi-stage game. There are multiple troughs and multiple peaks. A strict lockdown would show a downward trend in infection rates. Once this downward trend is observed, people would relax, giving rise to another cycle. Time lag between actions and payoffs further disincentives people in terms of their choices for appropriate actions.[1]

Until a vaccine is made and distributed around the world to prevent COVID-19 (which would take about 15 to 18 months), or an effective medication is made to cure COVID-19, the virus is here to stay. We will have to learn how to live with it by learning how to manage it.

[1] The way psychological model of individual decision-making feeds into an agent-based epidemic simulation and eventually contributes to disease transmission is a well-studied subject in the field of epidemiology. Perceived severity is directly related to appropriate behaviour modification and behaviour modification affects the perceived severity of an epidemic. Time lags between behaviour modification and resultant changes in perceived severity produce peaks and troughs. See study of A/H1N1 and Ebola by Q.L. Yan, S.Y. Tang and Y.N. Xiao in their paper on "Impact of individual behaviour change on the spread of emerging infectious diseases" at https://onlinelibrary.wiley.com/doi/epdf/10.1002/sim.7548

Lockdown Strategy – Understanding our limitations

Managing COVID-19 without vaccine or medicine requires social distancing and a lockdown is an excellent strategy for social distancing in the short run. Unfortunately, lockdown capacity is a finite source. Every country has a maximum reserve of resources, in terms of individual or household savings, social credit and stamina to survive without working. This stamina, when aggregated across households sets the limits for national stamina for lockdown: let us call it the national lockdown reserve (NLR). Broad-spectrum, long term deployment of NLR exhausts the society, depletes the resources, drains administrative capacities and compels significant sections of society to deviate.

In game-theoretic terms, social distancing is a cooperation game whose positive network effects only materialize if there is no significant deviation in its early phase. Imagine a two-period cooperation game where the cost of deviation in Period I (a time period when most of the populace is without immunity) is so high that even a minor deviation defeats the purpose of coordinated strategy. Fortunately, in Period II (when majority of the population has achieved immunity), deviation by a minority does not cancel out *positive network externalities*. For purposes of flattening the disease spread curve, Period II is not relevant but period I is critical. During Period I, even if a couple of dozen people from the neighborhood continue to meet for Friday prayers or for a weekend cricket match, the purpose of social distancing is defeated and the spread of the virus continues unabated.

A lockdown strategy as an administrative measure is excellent in terms of immediate suppression of the disease but a national lockdown of the entire country assumes that the nature and level of disease is uniform across the country. This is an incorrect assumption. In terms of chronological progression of disease too, there is an optimal timeframe with maximum payoff. Using our limited national stamina for lockdown only makes sense when the payoff in terms of averted spread of the disease is maximised.

III Sustainability of lockdowns

Within Pakistan's population of almost 220 million, there are thousands of internally well-integrated socio-economic zones with different levels of economic development and COVID-19 prevalence. Given these differences, a one-size-fits-all approach cannot work.

Let us assume that the disease spreads in clusters, as it actually does, and mass contamination happens only when clusters overlap. In such a decentralized and/or cluster model, the spread would be exponential but uneven. Therefore, a complete lockdown might be effective for a limited time to control the deepening of the disease (such as a fortnight) but it cannot stay forever. Social distancing measures will have to be relaxed in order to allow replenishment of the NLR, the national lockdown reserve: people will have to be given a chance to rebuild their capacity to withstand the rigors of the lockdown. If we are to assume that this is a multi-stage game, it will be

quite idiotic to exhaust a finite resource prematurely, especially when that resource gives us our only fighting chance.

Intelligent deployment of lockdowns

Keeping in mind unknown nature of this novel virus, it is appropriate to go for a differentiated approach towards lockdowns in terms of space as well as time. Different levels of lockdowns will have to be defined, with varying severities. On the softer end of the spectrum of a lockdown, soft measures (personal hygiene, ensuring 6 feet distance from each other, closing of places of daily communal interactions such as schools and colleges) might be good enough. On the stricter end of the spectrum, people would not be allowed out of their houses, food and groceries would be delivered in hampers at the doorsteps, and, other than in emergencies, human contact will be limited to other members of the household.

But a differentiated approach towards lockdowns can only be applied if different areas can be categorized on the basis of disease incidence or viral loads or viral reservoirs. These differences can then allow for an informed application of different levels of social distancing measures.

Ensuring maximum payoff through signaling

Before this differentiation is applied to inform the required severity of the lockdown, a signaling system is needed. This signaling system will allow us to identify pockets where disease incidence or spread is stronger or weaker. The immediate need of the hour, then, is to create micro viral maps of the entire country, with distinct boundaries. Without such a mapping, a decision support system cannot be enabled to maximize payoffs for consuming our finite stamina for lockdowns.

IV Zoning as a Corona Management Strategy

Rationale

The assumption of uneven transmission of the COVID-19 is at the heart of this paper. Given the transmission dynamics of COVID-19, an even spread of disease can only occur if two conditions are met: (a) space is homogeneous and (b) the motion of individuals is random and isotropic. Real world environments are heterogeneous and heterogeneity affects human motion as well human behavior.

If we look at the spatial distribution of COVID-19 across countries, the key assumption of uneven spread has so far withstood the stress test. Even within cities, COVID-19 spreads in clusters of socioeconomic interaction. The uneven spread of the disease thus necessitates decentralized containment strategies.

> An even spread of disease can only occur if two conditions are met:
>
> a. Space is homogenous
> b. The motion of individuals is random

Decentralized containment strategies become even more important when we factor in the finite resource constraint of *neighborhood lockdown reserve,* a national aggregate whereof is *national lockdown reserve* (NLR). Only the classification of geographic units on basis of disease incidence enables us to use distinct social distancing measures differentiated by level of severity. When households are grouped in geographic zones, the severity of lockdown measures (total curfew vs. ban on public gatherings) can vary according to disease levels or level of infecting potential. Moreover, because social distancing as a strategy hinges on cooperation of full neighborhoods, therefore, moving the full zones or full neighborhoods instead of households along the social distancing spectrum creates incentives for congruent households to exert social pressure on delinquent households for compliance. A robust testing regime that rewards or punishes the neighborhoods on degree of cooperation wards off the moral hazard of delinquent behavior. Countries like Pakistan, having no luxury for extraordinary payouts for national lockdown, have no option but to allow its congruent neighborhoods to function normally with minimalist precautions like ban on public gatherings and lock down only those neighborhoods that have dangerous levels of viral loads.

Zoning alone will not suppress the disease because spillovers can always occur. Therefore, the success of zoning strategy hinges on strict enforcement. If ever there was a time for strict governmental action, it would be in response to the challenge of COVID-19. The proposition is thus to divide the country into corona management zones and corona management circles. The principles behind this zoning are as follows:

Principle 1 – Defining Perimeters

The perimeter of the zone or circle should be a clearly demarcated boundary, one defined either by natural or man-made markers such as a road or a canal. The boundary markers should be easily identifiable, and easily communicable. Appropriate definition of the perimeter of a zone or circle is of critical importance. Economies are not organized on the basis of some arbitrary number of households but there is nonetheless the fundamental concept of a market town and its hinterland. If the relationship of the hinterland with the primary towns is respected while demarcating the perimeters, spillover effects (negative externalities) of quarantining certain zones or aggregate of zones can be neatly minimized.

Principle 2 – Ensuring social/cultural integrity

The perimeter of the zone or the circle should aim to take into account the existing social fabric of the area to ensure that existing social integrity of the zone or circle is maintained and existing social and cultural interactions are accommodated. This would be particularly true for rural areas and large urban centers. In fact, certain cities like Karachi are already in essence the sum of *many cities.*

Principle 3 – Ensuring economic viability

The zones should ideally be economically integrated enough that 80 to 90% of the economic activity of such zones should be internal to the defined zone. These little economic republics of sorts should ideally form a zone.

So how do we divide a country like Pakistan on these lines? Pakistan has roughly about 33,000,000 households. If each zone has 16,000 households, we will have 2,000 zones. Commercial or industrial areas can either be included as part of such zones or can be separated into independent zones with limited access.

Each of the zones can further be divided into 10 circles each, of roughly 1,600 houses. It is crucial to note that these zones and circles are not to be limited to the figures above. What is important will be geographic contiguity, easily identifiable natural boundaries and socio-economic cohesiveness, in determining a zone or a circle. Figures like 16,000 or 1,600 remain arbitrary and are subject to change should ground realities mandate a smaller or larger zone or circle.

An average sized district has three or four tehsils. A tehsil would have roughly four zones and 40 circles.

How quickly can zoning be done?

The Bureau of Statistics (BOS), has digitized maps of all census blocks, initially prepared for Census 2017. It has all the mauza boundaries for rural areas and census block boundaries for urban areas fully digitized. Because each data set corresponds to census data on households, it is an excellent base data layer for demarcating Corona Management Zones and Circles. Moreover, the entire road network (at least for Punjab) is digitized and available with NTRC (National Transport Research Centre). Similarly, canal networks data can be obtained from the irrigation authorities. If we integrate all these layers of boundaries with the deep local knowledge of different socioeconomic areas available with elected representatives, we can come up with a good zonal strategy. We can use different zoning strategies for different districts. For example, in the case of purely rural districts like Rajanpur, even a tehsil boundary would suffice. On the other hand, small cities can be clubbed together as a tehsil, while the large 50 cities will require more micro level zoning.

V Testing Strategy

One colossal global mistake

Testing remains extremely crucial for combating the spread of the disease. By and large, tests are being conducted on people who either report symptomatic, or have come into contact with people who have been symptomatic or are reported to be symptomatic. This strategy is sensible, given the limited capacity of testing. At the same time, this strategy is also colossally faulty.

Approximately 30% of the population infected with COVID-19 remains asymptomatic. These people serve as active carriers, as extremely potent viral vectors, of what is an already exponentially spreading disease. To make things worse still, the current testing regime has roughly a false negative percentage of 15 percent. This adds up to 40 percent of the infected persons. Given this blind spot, and the geometric rate of spread, this segment of the population -- apparently asymptomatic but silently infectious – is serving as the deadliest weapon in COVID-19's arsenal.

Without isolating the asymptomatic and the false negatives, roughly 40 percent remain at large, silently infecting their dear and near ones. With this 40 percent unidentified, total lockdown remains the only option because then one must assume that every individual is infected, until and unless proven otherwise. Without isolating this thirty percent *asymptomatic mass* and another 10 percent of *false negatives,* any relaxation of the lockdown would defeat the entire social distancing strategy.

Pooled Testing

To work around this problem, a lesson from Germany can be adopted immediately. To overcome testing limitations, Germany started testing pooled samples; 10 individual swabs/samples with different viral transportation mediums are collected, pooled into one, and tested. If the pooled sample result is negative, then all 10 people are cleared. With the cost of 1 test, you are able to test 10 people. If none are positive, you save the cost of 9 additional tests. However, if the pooled sample is positive, only those 10 people need to be individually tested. Not only does this serve as a cost-saving measure but the testing coverage of the country can be increased ten times, possibly 20 times over a much larger population without stretching resources. (See Annex A for details)

Sampling Strategy

For testing to be effective, and given the resource and capacity constraints that Pakistan has, our limited ability of testing has to be employed in a manner that gives optimal results. Pooled testing has already been identified as a way of resource optimization. To further make pooled testing an effective tool in drawing up data regarding disease incidence and spread, randomized sampling can serve as an effective strategy. The randomized sampling strategy will help in increasing the veracity and value of the data drawn from pooled testing. Subsequently, it will also help in targeting areas by identifying levels of infections across different areas.

> Testing remains the key to an effective fight against SARS-CoV-2

In employing randomized sampling, the aim will be simple; to reduce selection biases, heuristic biases and accidental biases. The goal, then, will be to draw enough data to inform the deployment of lockdowns. Lockdowns

(explained in Section VI), envisaged as a spectrum on which four distinct states have been identified, has already been imagined as a good (with the amount of good available envisaged as the national lockdown reserve). In cognizance of the fact that the good is limited, and not everyone requires the same extent of this good, the data that we aim to draw up, can help in increasing the equity of lockdown distribution. The data will help in employing adaptive triggering of various states of lockdown, ensuring that only after certain levels of the disease are signaled, a corresponding amount of the national lockdown reserve is utilized.

Our sampling strategy will determine the incidence of (i) infections i.e. symptomatic individuals with positive COVID-19 tests and (ii) prevalence of carriage (no symptoms but positive for nasal carriage of the virus). We will also collect variables such as the comorbid condition of participants, number of people in the house, previous respiratory tract infections other than COVID-19, duration and time of occurrence of that infection, interaction with anyone with COVID-19 infection or anyone who was later diagnosed with infection and travel history.

Stratification of Circles

The existing data currently being collected already provides us with a rudimentary starting point. It is currently estimated that COVID-19 infections belong largely to two categories; external infections (those who have travelled from abroad) and local transmission, and these two categories are, for the moment, geographically limited to certain localities.

As already discussed in section IV, the country will need to be divided into Corona Management Zones and Circles. Simultaneously, the existing data of positive patients can be mapped through GIS to identify their position. By super-imposing the GIS mapping of positive patients on the drawn-out Zones and Circles, we should be able to identify which positive patient belongs in which circle, across the country. This will serve as our primary starting point.

As a result of this plotting and stratification exercise, we should be able to identify three specific scenarios which may emerge.

Scenario A: 1 or more positive case in any circle

Scenario B: No positive case in circle itself, but circle is contiguously adjacent to a circle with a positive case

Scenario C: No positive case in circle itself, and circle is not contiguously adjacent to a circle with a positive case

Using these three scenarios, the proposed sampling strategy can be employed and pooled testing (as described above) can commence.

Drawing a Representative Sample

This categorization of circles would give us an educated estimate of which circles fall into which of the identified Scenarios (A, B or C).

Let us assume that x number of circles fall into Scenario A, y circles fall into Scenario B, and z circles fall into Scenario C (where x + y + z = 20,000 circles).

Based on current disease patterns and positive case trends, it is assumed that 1,000 circles will fall under Scenario A, 3,000 will fall under Scenario B, and 16,000 will fall under Scenario C.

For pooled testing,

- Out of 1,000 circles under Scenario A, 200 households from each circle will be selected for testing;
- Out of 3,000 circles under Scenario B, 200 households from each circle will be selected for testing;
- And out of 16,000 circles under Scenario C, 20% of the circles will be randomly selected, and 100 households from these 20% will be selected for testing.

The frequency of testing will also vary. For the 200 households per each circle being tested from x circles (Scenario A), testing shall be done every 2 weeks.

For the 200 households per each circle being tested from y circles (Scenario B), testing shall be done every 4 weeks.

For the 100 households per each circle being tested from 20% of *z* circles (Scenario C), testing shall be done every 4 weeks.

Based on these calculations, it is estimated that a total of 520,000 pooled tests annually will be needed for Scenario A, 780,000 for Scenario B and 416,000 for Scenario C.

Individual Testing

Pooled testing will help identify disease spread and aid in removal of the abject blindness with which the country might be operating. Through identification based on pooled testing, zones and circles drastically affected will be identified.

Individual testing will have to be conducted simultaneously to inform us of real time infection spread and incidence. Individual testing will be administered to four basic groups:

1. **Reported cases on the basis of presenting symptoms**
   These will be cases that are identified as showing all basic symptoms of COVID-19, such as fever, cough, breathlessness etc.

2. **Pooled Testing Positives**
   These will be individuals whose pool tests turned out positive

3. **Contact tracing of positive cases**
   These will be individuals that have come into contact with a positive patient in the last 14 days.

4. **Exposed population**
   These will be people that have direct lines of exposure to the virus. Possible groups will include medical staff, hospital management staff, frontline workers, families of medical staff and frontline workers, airport staff, especially pilots, flight attendants, and families of airport staff, ground level civil administration and families of ground level civil administration, essential travel drivers such as bus drivers (who will be helping maintain supply chains across the countries) and local delivery agents (who will be helping in delivering door to door services such as food delivery etc.) and families of essential travel drivers.

It is estimated that a total of 5000 individual tests will need to be conducted daily.

Total Testing Capacity and Cost

The table below summaries an estimation of the costing:

	A	**B**	**C**	**Individual Tests**
Circles	1,000	3,000	16,000	-
Number of samples per circle	200	200	100	-
Annual Frequency	26	13	13	365
Total number of households from whom sample to be drawn (annual) (millions)	5.2	7.8	4.16	1.825
Number of Tests (Annual)	520,000	780,000	416,000	1,825,000
Number of Tests (per Day)	1,425	2,137	1,140	5,000
Cost per test	14,500	14,500	14,500	5,500
Annual Cost (millions)	7,540,	11,310,	6,032,	10,037.5
Total Annual Cost (millions)				**34,919.5**

Table 1: Summary of Pooled and Individual Test Costs

Serological Testing

Asymptomatic nasal-carriage also elicits immune response resulting in generation of antigen specific antibodies. Screening with antibodies can also be performed in parallel with nasal carriage at a later stage. Serological testing can also be used to issue special cards to citizens for unrestricted entry into and from locked down zones.

VI Informed Social Distancing Strategy or Smart Lockdowns

This testing will allow for an intelligent application of the lockdown as a strategy to contain the spread of the disease. Testing results will allow for aggregation and disaggregation of zones, based on the extent of viral activity. For areas not as hard-hit, a controlled semblance of normalcy may be introduced with softer social distancing measures. Every fortnight, new data will help inform us fight the virus better without consuming NLR and place zones and circles in one of the following categories, thus keeping the country largely open and functional as, stylized here.

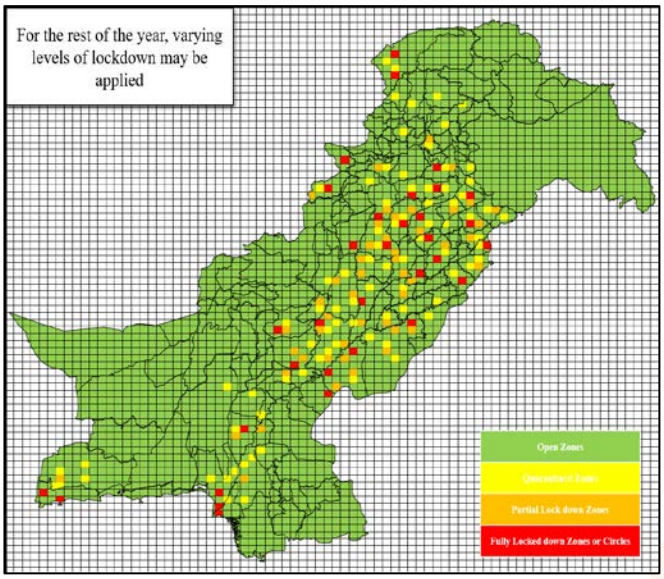

Figure 2: Sample deployment of smart lockdowns

Open Zones

In open zones, it has been suggested that life may continue as normal, possibly with restricted access to places of public gatherings such as gyms, mosques and schools etc. Economic activity may be allowed to continue with additional precautionary measures such as masks and gloves, etc.

Quarantined Zones

Quarantined zones are envisaged as internally fully open, externally quarantined, with cases isolated within the zone.

Partial Lock down Zones

Partial Lock down zones are envisaged as internally open, externally quarantined with some streets or neighborhoods fully locked down.

Fully Locked down Zones

Fully locked down zones will essentially be akin to a curfew. There will have to be a complete lockdown on movement in and out of homes in these areas.

Tentative Criterion	Type of Zone	Features
Less than three cases in any one circle, or more than one circle, as long as these circles are contiguous and all the contacts have been traced.	Open Zones (90 %)	Zone or Circle is both internally and externally open with only places of public gatherings closed i.e. gyms, schools, mosques etc. Economic activity is open with precautionary measures like masks and gloves.
More than two, but less than five cases in any circle or contiguous circles or a maximum of three cases in not more than two non-contiguous circles.	Quarantined Zones (5%)	Internally fully open, externally quarantined, cases isolated
More than four but less than 10 cases in any one circle or contiguous circles or a maximum of five cases in not more than two non-contiguous circles.	Partial Lock down Zones (3%)	Internally open, externally quarantined, but some streets or neighborhoods fully locked down
More than 10 cases in the zone or any number of cases in more than two non-contiguous circles.	Fully Locked down Zones (2 %)	Full lockdown with Curfew

Quartet of Fortnights of Abstinence

The question remains what if the data shows an infection in majority of circles. In this situation, a complete lockdown of 14 days will be observed in the entire country as shown in the stylized map here. Prior to the curfew-lockdown, ample time (a week or so) will be given for the population to prepare for a 14-day lockdown. People may travel back to their homes, with sufficient stocks for a long vacation to be spent with family alone. This lockdown may take place every quarter. Such lockdown will result in across-the-board suppression of disease, enabling us to have the luxury of targeted lockdowns for remaining 10

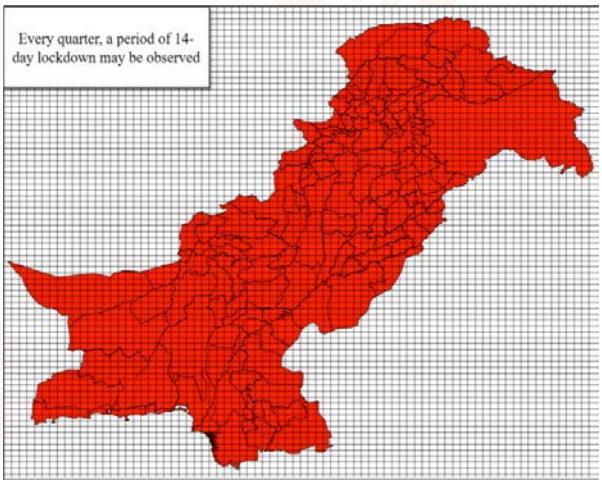

Figure 3: Quartet of Fortnights of Abstinence

months. Such fortnights of absence will also provide necessary relief to that little planet we call Earth.

VII Enforcement and Mitigation Measures for four distinct states of lockdown

> Irrespective of the state of lockdown, change in Human Behaviour will remain key to effective social distancing

During the lockdowns, for each of the stages identified above, key mitigation measures will also need to be taken simultaneously as ancillary support to ensure that the lockdown is effective in terms of disease control. While some spillover effects cannot be ruled out for Quarantined Zones and Partial Lockdown zones, these can be mitigated effectively if the job of perimeter control is entrusted to the troops of Pakistan army. If an initial fortnight of total lockdown is enforced religiously, the number of households under some kind of lockdown should not go above 10 percent. In such a scenario, there would not be more than 200 zones across the country requiring further lockdown which would be much more manageable in terms of administrative capacity.

Open Zones

For this level, key mitigation measures would be needed on two levels – internal behavior nudging and external movement control.

For internal behavior nudging, it will be crucial to introduce measures that keep citizens aware and armed to practice key social distancing measures such as public service messages, both electronic and in print, amply provided spaces to wash hands with soap, or public access to sanitizer, especially at essential areas such as grocery shops etc.

For external movement control, though these zones will be essentially open and accessible, it is crucial to ensure that they remain protected from any incoming disease. All entry points into these zones will need to be equipped with certain checks to ensure that individuals coming into the zone are either coming from another open zone, or in case their previous movements are untraceable, that they remain in contact with the authorities to report any symptoms that might present themselves up to 14 days after entry into the green zone.

Quarantined Zones

For this zone both behavior nudging and movement control checks (as described above) will continue. Added movement control will ensure that only essential persons and vehicles can enter

or exit the zone. Additional measures will also include setting up makeshift isolation facilities to ensure that cross-infection and local spread of the disease is controlled.

Partial Lock down Zones

In addition to the continuation of the measures listed above, for those areas where a full lock down is implemented, key barrier with enforcement staff will have to be set up. Movement in and out of these barriers will only be warranted upon presentation of a Government mandated Essential Person/Vehicle travel document (card/form/printout etc.). This documentation should clearly identify the person, the vehicle, the purpose, the destination and the estimated time within which the person/vehicle can be allowed into the completely locked down areas.

Considering that these zones will also present a higher number of cases, Mobile Health Units and Mobile Diagnostic Units may also be deployed to ensure that patients being quarantined or treated at home have localized access to healthcare, and are not forced to travel to healthcare facilities; possibly leaving a trail of infections in their wake.

Fully Locked down Zones

Since there will be complete cessation of movement, this will include ensuring that people are given access to every possible essential necessity at home. Contact-less deliveries will be encouraged, along with ensuring that in case rations need to be delivered, only specifically allowed persons/vehicles will be let in and out. The Government mandated essential person/vehicle travel documents will need to be issued, albeit in an extremely limited quality to ensure that no random movement is allowed on the streets.

Further discouragement of movement may be enforced in the shape of a penalty (either fine, imprisonment or both), in case any citizen is found violating the curfew.

VIII Technology, big data and surveillance states

In order to fight the spread of the virus, the WHO identified four crucial steps; isolate, test, treat and trace. For every country then, the goal is to find a way to implement these steps within their local contexts. Isolation, testing and treatment are mostly universal in their applications. Lockdowns and social distancing measures, testing techniques and treatment options remain largely the same; varying perhaps only in terms of local capacities and how much a country can do of each.

Tracing, however, presents a unique challenge.

Lockdowns, testing and treatments may allow for transmission chains of the virus to slow down. However, if there is no tracing, these transmission chains may continue to fester at lower levels;

waiting to strike again, once human behavior regresses to the state of complacency that allowed for the pandemic to spread in the first place.

To control these transmission chains, it is pivotal then, to trace contacts. Imagine a trajectory of 14 days: Person A goes about his affairs for the first 3 days, without showing any symptoms, and meets a total of 10 people. On the 4th day, he develops a cough and tests positive. He can identify 9 people he met, but the 10th remains untraceable. The 10th also remains an active agent in sustaining the transmission chain of the virus. Now imagine if for each of the 9 people identified by Person A, every 10th contact of theirs, remains untraceable.

To combat this challenge, technology has shown to be a useful aid.

In China, an application was developed to help identify if an individual was safe for travelling or using public spaces. People would enter their names, unique identity numbers, body temperatures and travel history. Big data would help assign either a green, yellow or red code to the people, based on the possibility of the person having come into contact with the virus. Checkpoints would only allow people with green codes to pass.

Similarly, South Korea used GPS locations to track all people quarantined immediately after landing in the country, to ensure their movements were traceable, should they develop any symptoms in the first 14 days of being in the country. Turning off the GPS tracker of the phone would earn the quarantined individual a strict message from the authorities.

Singapore's application, TraceTogether, also used mobile Bluetooth tracing to identify people who have come within 2 to 5 metres of distance with any user. The idea is simple; your phone number will act as a unique identifier of your identity and continue to transmit Bluetooth signals. Any other phone number coming within the defined perimeter of 2 to 5 metres would be dubbed as a contact. Should you develop symptoms, the app will draw up all numbers who have come in contact with you, thereby allowing authorities to trace and control. However, only 12% of the country using the application might render it ineffective.

In a bid to further the use of technology, Apple and Google have also joined hands to develop an app that would work on similar Bluetooth contact tracing. Estimated to be released in early May, the companies are calling their software Privacy-Preserving Contact Tracing. This software will allow countries to employ both iOS and Android compatible applications which can use Bluetooth technology to trace contacts without compromising on the privacy of people by exposing their locations or possibly sensitive personal data.

Concerns over misuse of data have already been raised by advocacy groups. While tracking and identifying possible new cases is crucial in breaking transmission chains, there is a very real chance of big data usage ultimately leading to an infringement on civil liberties and invasion of privacies.

China's surveillance went beyond just app utilization; public transport systems and public CCTV footage was also used to identify movements. There is valid apprehension that these measures might become a permanent fixture of the Chinese surveillance state, coronavirus or no coronavirus.

While saving lives is important, using big data to decrease personal liberties might open the door to a very dystopian future. It would be remiss not to stress that development of contact tracing applications is important but that it is equally important is to protect the public's right to privacy.

IX Fiscal Impact of implementing the signal-driven approach

The case of opening the economy while more strictly implementing rules of quarantine, isolation and social distancing where needed does not need to be justified. It has its own merits in terms of lives and livelihoods saved. Still, there is a strong economic and fiscal case for liberal spending on testing and enforcement.

In this section, we try to compare the potential gain pursuant to implementing this approach versus the existing government approach. The existing government approach is primarily defined by a complete lock-down period and opening selected sectors of the economy with a possible full lockdown in future (with uncertain timing) as there will be spike in cases in future. Our approach as presented in this paper is primarily about opening geographic area as against sectoral opening, with limited lockdown periods using the zoning approach. We anticipate that with this approach we will be able to open 90% of the country and related economic sectors. In this approach the lockdown period will be predictable and notified in advance so the economic actors can be prepared in advance minimizing the losses as compared to any sudden shutdown. Similarly, this will advocate for adjusting of work holidays in such a way that lock-down periods can be declared as holidays, whereas, the other holidays can be converted into workdays minimizing the productivity loss.

For ease of referencing, we will call the government's existing approach as 'Approach A' and the proposed approach in this paper as 'Approach B'. Projections related to Approach A have been obtained from analysis done by Engro[2]. We compared the estimates by Engro with similar estimates done by the Pakistan Institute of Development Economics (PIDE).[3] The comparison found that largely the estimates of both these studies were not very different. PIDE estimates were on the higher side as compared to Engro, however, we used Engro estimates as these are more detailed. We will compare the impact of implementing Approach B with the estimations made by Engro.

[2] COVID-19: Scenarios and implications for Pakistan

[3] COVID-19: Bulletin number 17, PIDE.

Implementation of Approach B will lead to the opening of more than 90% of the areas with minimal lockdown. This will result in increased economic activity. Based on the assumption of 90%+ opening of areas and economy we have re-adjusted the estimates made by Engro. The table below compares both these scenarios. It is expected that implementation of Approach B will lead to reduction in unemployment rate from 16% to 7%, saving 5.6 million people from being unemployed. Similarly, the reduction in GDP as a result of implementing Approach B from base will be 8% as compared to 18% under Approach A.

It is worth mentioning here that in our estimates, the reduction under Approach A is on the lower side, while the actual reduction can be higher. Approach A assumes R<1 over the next twelve months which may not be possible to achieve (and hence the actual impact may be more). We did a simple analysis to estimate if R>1. As per our estimates, the unemployment can be as high as 19% and reduction in GDP as high as 23%. Therefore, we are already comparing Approach B with conservative estimates of reduction in GDP and employment.

Sectors	GDP - contribution	Total employees	Reduction		Impact on GDP		People losing jobs	
			Approach A	Approach B	Approach A	Approach B	Approach A	Approach B
Agriculture, forestry and fishing	57,120	24.0	-7%	-3%	53,122	55,406	2.0	0.9
Wholesale and retail trade	55,767	10.0	-20%	-7%	44,614	51,863	2.0	0.7
Manufacturing	38,499	10.0	-20%	-7%	30,799	35,804	2.0	0.7
Transportation and comms	38,000	4.3	-20%	-7%	30,400	35,340	1.0	0.4
Real estate sector	19,130	0.3	-50%	-25%	9,565	14,348	0.2	0.1
Education	6,000	3.0	-30%	-20%	4,200	4,800	2.0	1.3
Others	79,000	10.7	-15%	-8%	67,150	72,680	1.0	0.5
Total	**293,516**	**62.3**			**239,849**	**270,241**	**10.2**	**4.5**

Table 2: Impact on GDP and Employment – USD in Billions

We also modelled the impact of Approach B on fiscal deficit. Under existing scenario, estimates are that the fiscal deficit could increase by PKR 2.16 trillion. However, if Approach B is implemented, we estimate that this fiscal deficit could be reduced to PKR 0.984 trillion, a reduction of PKR 1.176 trillion.

Details	Approach A	Approach B

	Expenditure/lost revenue	Revenue	Expenditure/lost revenue	Revenue
Interest Servicing	-	550	-	550
Public Sector Development Programme	-	175	-	175
Foreign aid	-	550	-	550
Tax revenue	1,600	-	840	-
Petroleum levy	80	-	67	-
Food support	400	-	200	-
Health expenditure	250	-	300	-
GDP support	500	-	300	-
PM Package excluding food	525	-	500	-
Increased SOE funding	80	-	52	-
Total	**3,435**	**1,275**	**2,259**	**1,275**
Net impact on fiscal deficit		**2,160**		**984**

Table 3: Fiscal Deficit Impact – PKR in Billion

The table above presents the details for fiscal deficit, The additional costs of implementing the signal-driven approach have been adjusted in the above calculations under the heading 'Approach B'. Notes for above calculation may be seen at Annex B.

X Final Note of Caution

The national lock down must continue till we have reliable data on the incidence of COVID-19, collected through robust testing of households selected via representative sampling. Zoning can be done in three days and if the state really moves into action, first round of testing can be conducted through pooled method within ten days. Any other approach including incremental opening of the country may lead to disaster of a kind this country has never seen before.

Annexure A: Pooled Testing

The concept of test pooling (mini-pool testing) is not new, this technique has been adopted in the past for Hepatitis and HIV screening in settings with limited resources. According to experts, test pooling can be used for detection of SARS-COV-2 also. This entails laboratory investigations in which swab samples (depending upon the capacity of viral transport medium to hold samples, usually ranging from 2-6) from mucous membranes of the throat or nose are combined using specified procedures in a buffer solution, and subsequently tested using what is known as the PCR procedure (polymerase chain reaction procedure, direct genome detection of SARS CoV-2). In the case of a negative result, all included samples have a reliable negative result. In the case of a positive mini-pool result, individual testing is carried out in previously reserved samples. The positive sample can then be identified within 4 hours. On the basis of these laboratory results, in particular large cohorts and testing on asymptomatic individuals can be carried out, allowing a massive savings of test kits in particular. This procedure makes it possible to immediately and dramatically increase testing capacities for detecting SARS-CoV-2 in larger population groups as being demanded by all public health specialists, because the more people who can be reliably tested for SARS-CoV-2, the faster the pandemic can be curbed.

Financial impact of pooled method vs standard method

Sr. No.	**Item**	**Cost for 10 persons (minipool method)**			**Cost for 10 persons (non pooled method)**
		Quantity	Unit Cost	Total Cost	
1	Viral Transport Medium (VTM)	1	1000	10,000	10.000
2	Extraction and Diagnostic Kit	1	4500	4500	45,000
	Total (PKR)			**14,500**	**55,000**

Annexure B: Optimal Group Testing

Determination of Optimal Testing Group Size and Expected Number of Deconfined individuals per Test:

The group testing proposed here is based on Dorfman (1943) and Gollier (2020) which characterize the size of the group testing that maximizes the expected number of people that can be freed from confinement. Following their methodology, let *n* denote the size of the groups to be tested regarding the disease with prevalence ratio of p. If *n* is too large, too many groups will be detected with the virus, and that will reduce the expected number of people who will be allowed to get back to work. Technically, *C* would be the frequency of groups tested negative which is equal to $C = (1-p)^n$, and the expected number of individuals freed from confinement with a single round of testing would be $K = nC$. The assumption behind this formulation is the independence of the health status within the group members conditional to belonging to the group.

The optimal size of group based on this methodology of testing thus satisfies the following first-order condition of *K* with respect to *n*:

$$n^* = \frac{-1}{log(1-p)} \approx \frac{1}{p}$$

The optimality condition conveys a very intuitive result, implying the optimal size of the group should be decreasing with prevalence ratio. It is efficient that the optimal group size be approximately equal to the inverse of the prevalence ratio. Using $n^*$and C^*, then the expected number of people back to work with a single test:

$$K^* = n^* C^*$$

Here the optimal expected number of people going back to work with a single test is also decreasing with the prevalence ratio. Table below characterizes the optimal strategy for different prevalence ratio:

p	n^*	K^*
0.01	99	36.60
0.05	19	7.17
0.1	9	3.49
0.15	6	2.26
0.2	4	1.64
0.25	3	1.27
0.3	3	1.03
0.35	2	0.85
0.4	2	0.72
0.45	2	0.61
0.5	1	0.50
0.55	1	0.45
0.6	1	0.40
0.65	1	0.35
0.7	1	0.30

Table Note: For $n^*$the lower bound is assumed

Annexure C: Notes for calculating GDP impact and fiscal impact.

Sector	Notes
Agriculture, forestry and fishing	Compromised sowing in May 2020 and reduction in commodity prices by 3%
Wholesale and retail trade	Minimal reduction in necessitates and reduction in luxury buying net impact 10%
Manufacturing	Reduction in items such as cement, autos etc. overall impact 10%
Transportation and comms	Reduction in line with manufacturing reduction 10%.
Real estate sector	Weak economic outlook – investor confidence – existing projects to continue - government package will help in 12+ months – reduction 25%
Education	Fee reduction due to shut down, dropouts to increase with income decline

Table 4: Notes for GDP Impact Calculations

Areas	Approach A	Approach B
Interest Servicing	Outstanding local debt ~ Rs. 22 trillion (13 trillion is long term). Decline in domestic interest rate by 375 bp (225 to-date) and foreign interest rate by 75 bp (foreign debt of $87 bn)	Outstanding local debt ~ Rs. 22 trillion (13 trillion is long term). Decline in domestic interest rate by 375 bp (225 to-date) and foreign interest rate by 75 bp (foreign debt of $87 bn)
Public Sector Development Programme	20% Reduction in PSDP spending as capacity to implement these projects will be curtailed	20% Reduction in PSDP spending as capacity to implement these projects will be curtailed
Foreign aid	Total aid of $ ~3 bn (IMF: $ 1.4bn, ADB: $1.25bn, WB: $0.6bn, Others $ 05mn)	Total aid of $ ~3 bn (IMF: $ 1.4bn, ADB: $1.25bn, WB: $0.6bn, Others $ 05mn)

Tax revenue	Assumes reduction in tax by ~30% from tax-base of Rs. 5,200 bn for 2020; this results from GDP contraction of 13%	Assumes reduction in tax by 15% from tax-base of Rs. 5,200 bn for 2020; this results from GDP contraction
Petroleum levy	Levy declines 30%; due to 10% lower fuel consumption, and 20% levy reduction to manage inflation	Levy declines 25%; due to 10% lower fuel consumption, and 15% levy reduction to manage inflation
Food support	Food support cost for the affected population (Rs. 150-170b in Suppress, & Rs. 200-280b in Sustain) net of private donations of Rs. 40 bn (Sec A: 0.25%, & Sec B: 0.1% of annual income)	Reduction in food support cost as compared to Approach A as lower level of employment assumed.
Health expenditure	Health expenditure estimated at 0.5% of GDP, based on stimulus packages in Russia and Mexico	Health expenditure estimated at 0.5% of GDP, based on stimulus packages in Russia and Mexico in addition the cost for implementing Approach B (PKR 50 billion)
GDP support	Additional 1% of GDP stimulus expected going forward	Additional 0.6% of GDP stimulus expected going forward
PM Package excluding food	Rs. 140 bn for wheat procurement (~50% subsidy assumed), net Rs. 10 bn for export package (concessionary loan impact), Rs. 100 bn SME, Rs. 100 bn emergency fund, Rs. 125 bn others	Rs. 140 bn for wheat procurement (~50% subsidy assumed), net Rs. 10 bn for export package (concessionary loan impact), Rs. 100 bn SME, Rs. 100 bn emergency fund, Rs. 125 bn others
Increased SOE funding	For PIA & Railways, 25% reduction in revenues, & decline in oil prices passed through: for profitable SOEs, Rs.10 bn reduction in dividends (15% of total)	For PIA & Railways, 15% reduction in revenues, & decline in oil prices passed through: for profitable SOEs, Rs.10 bn reduction in dividends (15% of total)

Table 5: Notes for Fiscal Impact Calculations