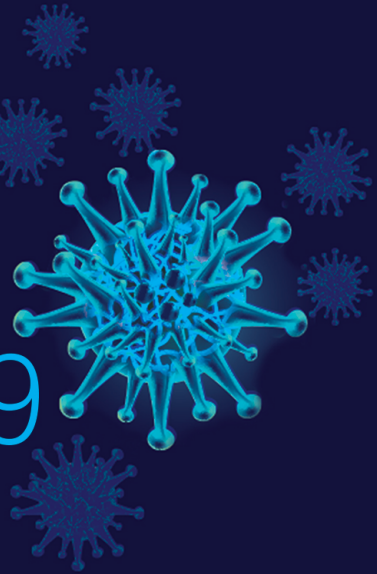# Data Driven
Decision Making
(DDDM) for
COVID-19

T.S.G. Peiris

DATA DRIVEN DECISION MAKING (DDDM) FOR COVID-19 IN SRI LANKA

DATA DRIVEN DECISION MAKING (DDDM) FOR COVID-19 IN SRI LANKA

T S G PEIRIS

Randhi Printers

FORWARD

Fact remains that it is required make decisions by all, at all times in real life. Some decisions can be trivial i.e. what to have for breakfast. Whereas there are those instanced having to make decisions which are life changing and complex. Type of decisions to be made has a wide range. Decision making involves having to choose a solution(s) to problems or uncertainties.

Accordingly, there can be different types of decision-making processes. The decisions can be made intuitively or based on facts/information/data or reasoning. It can be combination of both. Either way, the decision should be effective and more meaningful. Therefore, it is very important to make effective decisions in solving problems. More often the decision making will be ineffective and baseless due to insufficient information/data/facts. Also, too much of unrelated data, too many people with vested interest, attachments, biasness etc. could lead to poor or bad decisions that could lead to disasters destructions.

"Decision science" is a latest word coined to describe the collection of quantitative techniques used to inform decision making at all levels. i.e. individual or population levels. "Data Science" is also another word that is coined to extract insights form the analysis of data. Transforming the extracted insights to meaningful actions could be described to differentiate the Decision Science from Data Science.

As a Professor in Applied Statistics at the prestigious University of Moratuwa, Professor Sarath Peiris has demonstrated the relevance and power of both "Decision Science" and "Data Science" addressing the Covid-19 issue, through this book. This publication is also a testimony of the social responsibility of an academic and beyond. This effort is an exemplary to the entire University community and we at the University of Moratuwa sincerely acknowledged this publication which is a collation of series of newspaper articles addressing timely social problem thorough statistical tools providing sound scientific reasoning for policy making.

Prof. K K C Kapila Perera
Vice-Chancellor
University of Moratuwa
Katubedda, Moratuwa 11400
Sri Lanka

PREFACE

Statistics is a versatile subject which deals with variability, a common phenomenon in real life. To explain almost all the phenomena in real life, the explanatory statistical analyses and inferential statistics are used. Making decisions based on the results of statistical analyses is more scientific and effective in decision making than making decisions by experience or by own judgment. Data, when properly collected and utilized, can provide information which is unbiased. The process of taking decisions based on statistical analyses is known as 'data driven decision making (DDDM)'. I consider data (primary data and secondary data) is the heart of strategic decision making in the process of epidemiology, as the inferences derived from data analysis can provide to discover useful information for various decisions and future actions that improve their process.

On February 11, 2020 the World Health Organization declared a novel coronavirus outbreak, first identified in Wuhan China. It was named as COVID-19. The first infections were linked to a live animal market, but the virus is now spreading from person-to-person. It has now spread in about 215 countries including Sri Lanka. In Sri Lanka first person was detected on 11 March and by 20th July, 2020, 2715 positive COVID-19 cases have been identified in Sri Lanka.

No doubt that doctors have to play a very significant role with the help of other staff in various categories. Of course Sri Lanka has done tremendous attempt to control the virus and I believe that we are one of the best countries in controlling this virus among other countries like New Zealand, Iceland, Hong Kong. etc. Nevertheless, other scientists including statisticians also have to play a major role in their specialty to help the doctors and decision makers for effective and efficient decisions. With available data in the website of the Ministry of Health (*https://hpb.health.gov.lk*) I analyzed them from time to time (10th April to 13th July) and derived conclusions and recommendation based on DDDM and published seven newspaper articles in Daily News for the benefit of decision makers on COVID-19. This book consists of those seven articles for future reference.

Prof. T S G Peiris
Senior Professor in Applied Statistics
Department of Mathematics
Faculty of Engineering, University of Moratuwa
Katubedda, Moratuwa 1040
Sri Lanka

TABLE OF CONTENT

Article 1

SOME THOUGHTS ON COVID-19 IN SRI LANKA STATISTICAL ANALYSIS

COVID-19 is a new viral illness that can affect respiratory system of a person. It has now spread in 211 countries (*https://virusncov.com*) in different intensities. The World Health Organization (WHO) has declared the COVID-19 as an outbreak with a global health emergency in January 2020. The experts at Johns Hopkins Medicine, Baltimore, USA claim that Corona virus was totally unprecedented. The normal life of Sri Lankans has been highly affected by this outbreak since middle of March although we do not have a higher intensity like in other countries. Based on available data in different countries, it is very unlikely that COVID-19 spread in Sri Lanka much faster. Thus we need to provide evidence-based scientific conclusions to the Ministers and the higher officials in order to make their decisions more rational.

Comparison among Selected Countries

I have noticed that the daily trend of new COVID-19 cases in Sri Lanka compared to the daily trend of new cases in Italy is inconclusive. Because I have noted that there is no significant correlation ($r = 0.06$) between the two trends. Furthermore, the basic autocorrelation analysis suggests that the number of cases in Sri Lanka seems to be happening randomly, while in Italy there is a significant dependence structure.

Thus, in my opinion, it is not reasonable to say that we need to wait for some more days to see the spread of the disease based on the trends between the two countries. This would mislead the decision makers for some extent.

I believe the following statistics and conditional probabilities (Table 1.1) can be used to estimate the pattern in the future. I used the data extracted from the world COVID-19 website: *https://virusncov.com* for 6 countries including Italy and India.

Table 1.1: **Some Statistics and Probabilities on COVID19 based on Data up to 6ᵗʰ April**

| Country	Number of cases			Of the active percentage of		Of the closed Percentage of	
	Total	Active	Closed	Mild	Critical	Recovery	Death
Italy	132,547	93,187 (70%)	39,360 (30%)	96%	4%	58%	42%
Sri Lanka	178	135 (76%)	43 (24%)	96%	4%	88%	12%
UK	51,608	46,100 (89%)	5,508 (11%)	98%	2%	2%	98%
South Korea	10,331	3,445 (33%)	6,886 (77%)	98%	2%	96%	4%
Sweden	7,206	6,524 (91%)	682 (9%)	91%	9%	30%	70%
India	4,778	4,267 (89%)	511 (11%)	100%	0%	73%	27%

Based on the results in Table 1.1, the following conclusions can be drawn for the attention of policy-makers and doctors who are engaged in the fight against COVID-19.

- The number of total cases by far is extremely low in Sri Lanka compared to other countries. In almost all countries, the percentages of active cases are more than 70% with an exception in South Korea.

- Of those active cases, the percentage of critical cases is less than 5% with an exceptional situation in Sweden. In Sri Lanka it is 4%. This is indeed a good indication to say that we do not have a higher number of active cases at present.

- That is, if we test another 10000 suspected individuals, we would expect only 96 critical cases which Sri Lankan health system can manage.

- It should also be noted that the above conditional probabilities can be used as good estimators for long term predictions as those findings were based on more number of days.

- However, of the closed cases, the percentages of either dead or recovered are varied among the countries.

- The recovery rate has been the highest in South Korea (96%) followed by Sri Lanka (88%). That shows the good work of the Sri Lankan medical staff and other supportive staff.

- These results very clearly indicate that COVID-19 does not spread as fast as in other countries, provided that people are abide by the instructions issued by the health authorities.

Short-Term Prediction of Total Cases

Due to random nature it is not easy to model new cases of COVID-19 in Sri Lanka. However, based on the temporal pattern a crude estimation for new cases is possible on daily basis and the predicted value for 7th April is 7±4.
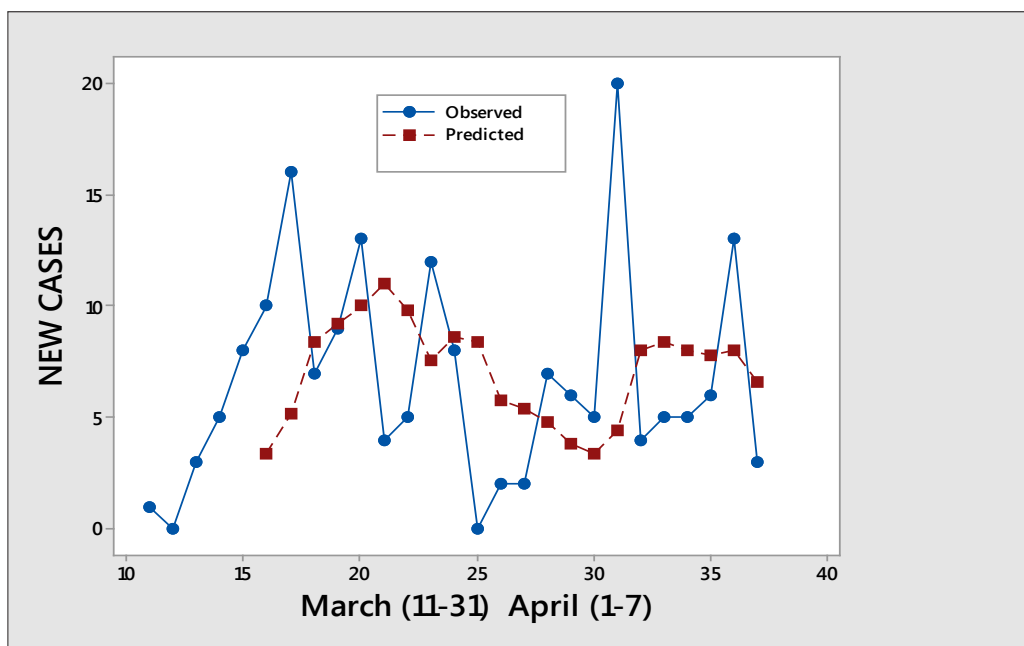
Figure 1.1: *Short-term Prediction of COVID19 New Cases*

Estimating R_O Based on Case Count Approach

Based on the local daily data available on the websites from 13 March to 6 April, I was able to compute the number of Freely Moving Infected (FMI) cases and Currently Infected (CI) cases on daily basis assuming that each FMI case roams for 5 days.

The total number of FMI cases during the above period = 759

Total number of CI cases during the above period   = 129

However, as we have not yet tested all the possible cases and doctors are claiming that all the positive cases so far not detected, the total number of CI cases was assumed as three times the actually infected cases during that period. Thus a proxy value for R_0 can be taken as, $\frac{(3*129)}{759} = \frac{387}{759} = 0.51$[95% CI= (0.47, 0.55)].

If the actual value was used the R_0 is 0.17 [95% CI = 0.14 and 0.20]. All these results confirm that the R_0 value for COVID-19 in Sri Lanka is less than 1, provided people follow the health instructions. Assuming the expected number of COVID-19 cases reported on 07 of April is 387, I computed the expected number of COVID-19 cases in Sri Lanka by 5 days

intervals till 08th of May. This is only for the use of policy makers, but I did not use the actual values due to obvious reasons explained above.

Table 1.2: Expected Number of COVID-19 Contacts

Day	Predicted value	95% CI
07 April	387	
12 April	197	[182 213]
17 April	101	[85 117]
22 April	51	[40 64]
27 April	26	[19 35]
02 May	13	[9 19]
02 May	7	[4 11]

Distribution of COVID-19 among Districts

So far no single positive case has been identified in the district of Anuradhapura, Polonnaruwa, Ampara, Monaragala, Trincomalee, Kilinochchi, Mannar, Mullaitvui, and Vavuniya. Since the population density is relatively low in those districts, one can think of relaxing curfew for those districts to resume normal work, provided travel between districts is prohibited.

Recommendations

It has now passed nine weeks since we diagnosed first COVID-19 on 28 January, though the second one was diagnosed on 12 March. Therefore, based on results in this study, the following recommendations can be made.

- It can be confirmed that the R_0 value for COVID-19 is less than 1.

- The COVID-19 in Sri Lanka does not spread as fast as in other countries, provided people follow instructions issued by the health authorities.

- Among the closed cases, the probability of recovery is very high in Sri Lanka (88 %?) and it is almost close to the corresponding value in South Korea (96%).

- Therefore, we should not wait to start our normal work until the rate of spreading of disease becomes zero.

- Not allowing to travel between districts should be continued for some time, but at the same time some relaxation should be offered to those districts that have less risk of transmitting the disease among the community.

- Curfew can be relaxed at different settings such as selected AGA Divisions within in a district at selected but different times.

- In those selected districts the government and private sector institutions and other facilities can be allowed to resume their work under certain conditions if required.

- Testing centers and field hospitals can be setup while using PCR as the primary method of testing as instructed by senior medical experts.

- Government should take the service from other professionals as well.

- After few weeks, we can even allow to enter people to Sri Lanka provided we can confirm that they are not COVID-19 carries using high technology at the airport and the cost involves for those tests should be charged from the incoming passengers. Then we should not depend on the tests done at other end.

Article 2

COVID-19 CURVE IN SRI LANKA

Published on Saturday, 18ᵗʰ April, 2020 in Daily News

http://www.dailynews.lk/2020/04/18/features/216704/covid19-curve-sri-lanka
*https://epaper.dailynews.lk/Home/ShareArticle?OrgId=ceb33ad4&imageview=1*

COVID-19 is a new illness that can affect the lungs of person which has now spread in 205 countries in different intensity. The number of total cased vary from 215,300 in USA to one in Papua New Guinea. Sri Lanka ranks 105 with 140 cases. CID-19 is caused by a virus known as coronavirus. There is still no vaccine or cure for it. In this article few l analyses are carried out on COVID-19 data in Sri Lanka which can be used for some policy decisions.

Trend of Daily COVID New Cases
Based on the data on 01 April, in almost all highly infected countries the daily variability of the new covid19 cases has been increasing exponentially (Figures 2.1-2.3). In contrast, the temporal variability of the new cases for the same period in Sri Lanka is totally different from other countries. It has been slowly increase exponentially up to 17 March and then has been decaying with an exceptional of 20 on 31 March (Figure 2.4).
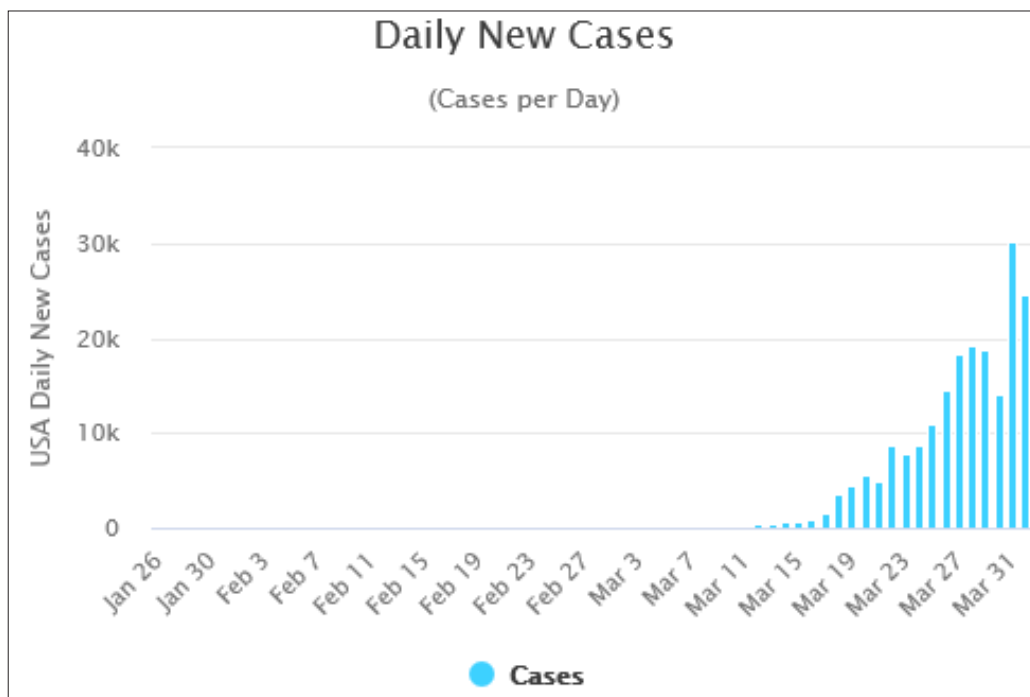
Figure 2.1: Trend of new Covid-19 cases in USA
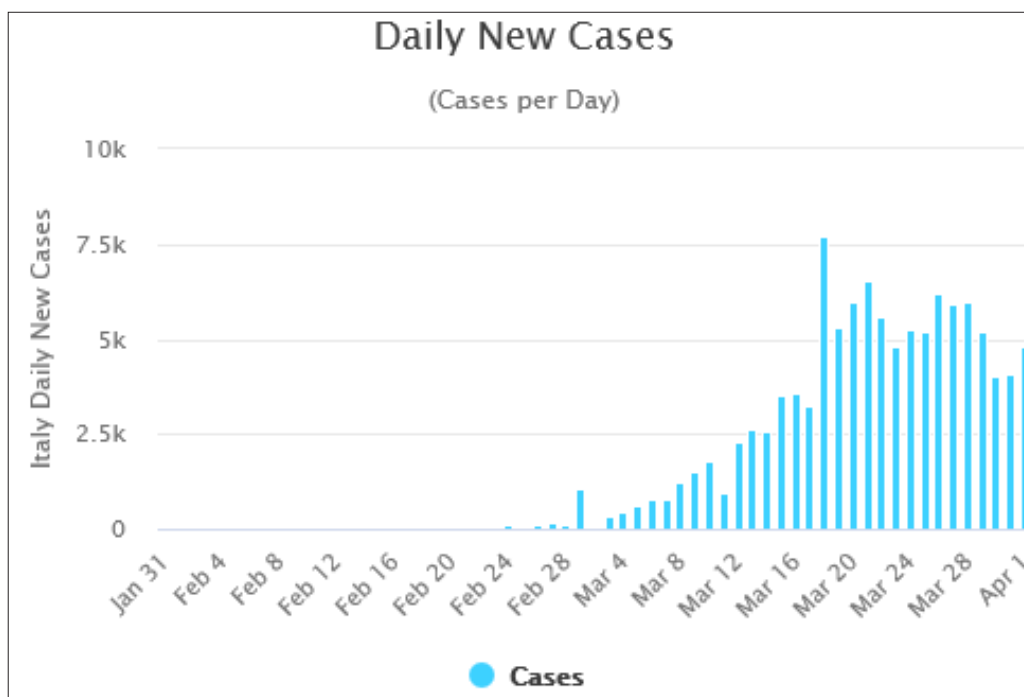
Figure 2.2: **Trend of new Covid-19 cases in Italy**
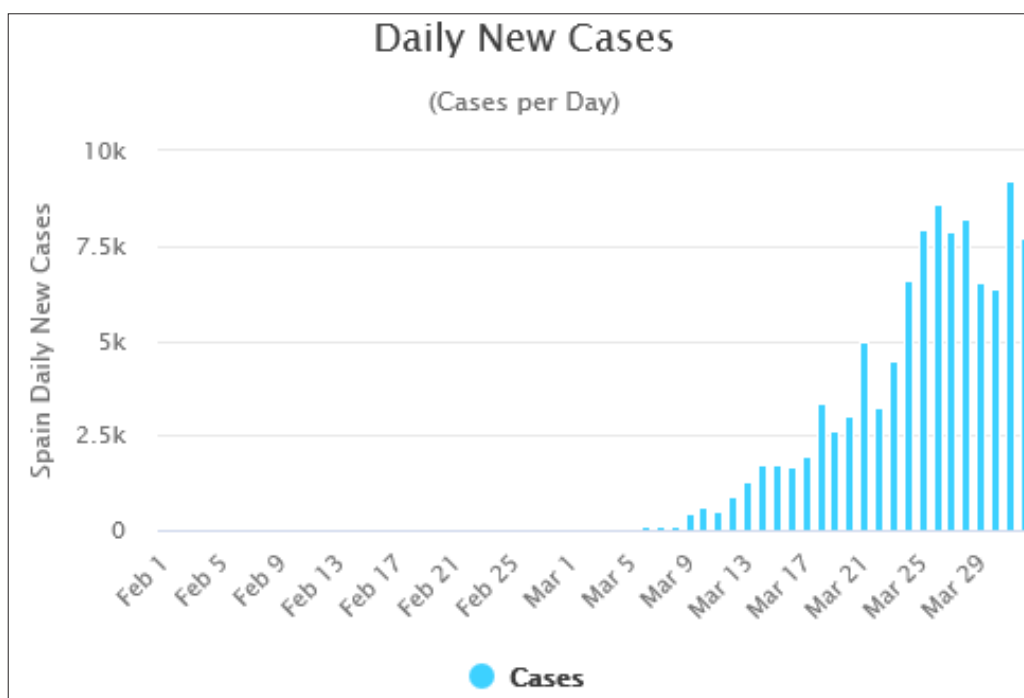
Figure 2.3: **Trend of new Covid-19 cases in Spain**

Figure 2.4: **Trend of New Covid-19 cases in Sri Lanka**

These results confirm that spread of COVID-19 will die off in few months' time and the probability of spreading to community level is almost zero as so far we have identified individual level and extremely few cases on family level.

Impact of Climate on COVID-19

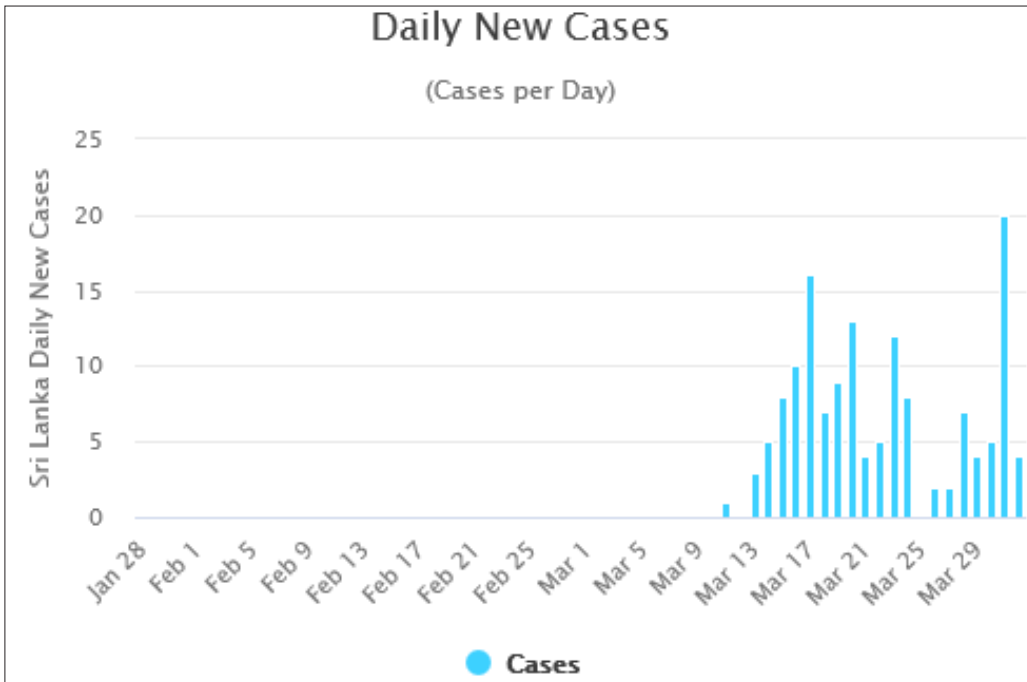Many studies have shown that high temperature and high humidity reduce the transmission of COVID-19. Transmission of COVID-19 was highly efficient at 5°C but was blocked or inefficient at 30°C. Dry conditions (20% and 35% RH) were also found to be more favorable for spread than either intermediate (50% RH) or humid (80% RH) conditions. A very recant study based on temperature and relative humidity using 14 countries claimed that an increase of one degree Celsius and 1% relative humidity increase substantially lower the virus's transmission.

An indicator known as, "R naught" (R_0) which is used by epidemiologists to estimate the individuals that each infected person will transmit. In other words, R_0 tells the average number of people who will catch a disease from one contagious person. Recent studies further claimed that in cold dry weather, of coronavirus is between 2 and 3, and for every degree Celsius increase and every percent relative humidity increase, R_0 reduces by 0.0383 and 0.0224 respectively. Thus, it is obvious that the expected value of R_0 in Sri Lanka (300C and 80% RH) can be between 1.5 to 0.8. However, it is better to compute proxy value for R_0, based on Sri Lanka data.

Expected Number of COVID-19 Cases

Pattern of COVID-19 outbreak is explained by daily by almost all media through the Ministry of Health. Recently, it has been mentioned that 500 infected individuals are circulating within the population by 18th March and those would have had a total of 19,000 contacts (19531), based on R_0 as 2.5. However, I also computed expected number of infected cases for different R_0 values assuming initial value on 18th March as 500. This computation can be easily done using basic properties on geometric progression in arithmetic (Table 2.1).

Table 2.1: Expected number of COVID19 contacts cases in different dates for various R_0 values taking cases on 18th March is 500

Date	R_0 values				
	2.5	2.0	1.5	0.8	0.5
18-Mar	500	500	500	500	500
23-Mar	1250	1000	750	400	250
28-Mar	3125	2000	1125	320	125
02-Apr	7813	4000	1688	256	63
07-Apr	19531	8000	2531	205	31
12-Apr	48828	16000	3797	164	16
17-Apr	122070	32000	5695	131	8
22-Apr	305176	64000	8543	105	4
27-Apr	762939	128000	12814	84	2

Though it says, cases of COVID-19 that fly under the radar without being diagnosed which appear to fuel the rapid spread of the disease, we must get a reasonable value. Almost all the cases we used to take for quarantine either in hospitals or other places are not positive cases. Furthermore, those who self-quarantine cases are almost not positive cases. Since we have found only 144 cases by 1st April (and 51 on 18th March), I took my liberty to compute COVID19 contact for different R_0 taking the initial value on 18th March as on 1.5*144 =216 (Table 2.2).

**Table 2.2: Expected number of COVID19 contacts when cases =216 on 18th March**

Date	R_0 values				
	2.5	2.0	1.5	0.8	0.5
18-Mar	216	216	216	216	216
23-Mar	540	432	324	173	108
28-Mar	1350	864	486	138	54
02-Apr	3375	1728	729	111	27
07-Apr	8438	3456	1094	88	14
12-Apr	21094	6912	1640	71	7
17-Apr	52734	13824	2460	57	3
22-Apr	131836	27648	3691	45	2
27-Apr	329590	55296	5536	36	1

It is obvious if R_0 is less than one numbers are decreasing and if R_0 is greater than one numbers are increasing with time. Based on the results in Table 2.2, the number of infected cases in Sri Lanka by 17 April would be 2460. Based on the values in Table 2.1, it can be assumed that he R_0 value of 2.5 is somewhat unrealistic.

Relationship between Infected Cases vs. Percentage of Exposures

If it is assumed that one person who is asymptomatic for five days and doesn't practice social distancing one infected person can spread the virus to 2.5 people, the relationship between % exposure and infected person after 30 days can be easily found using the sum of geometric progressive series (Figure 2.5).

The total amount of infected person at 30 days is 406, if 100% less exposure. Based on the same assumption if 50% less exposure, the total amount of infected person at 30 days is = 15. For 75% less exposure the corresponding number is less than one. These results clearly show the impotence non-exposure.
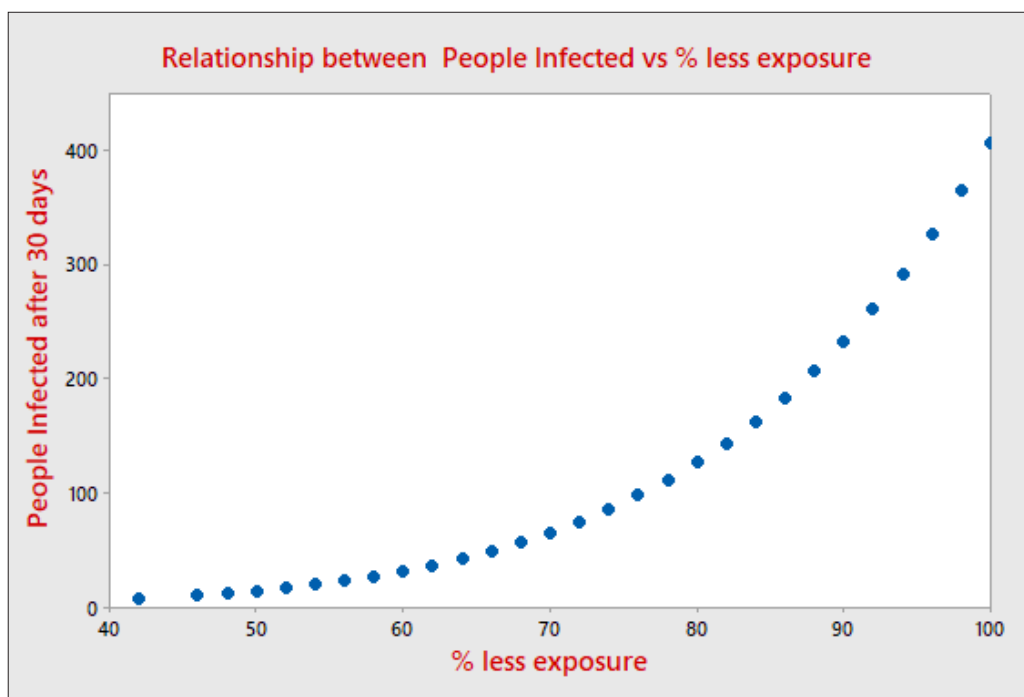
Figure 2.5: *Relationship between People Infected vs % Less Exposure*

Conclusions

- The R_0 value of 2.5 for COVID-19 in Sri Lanka is bit unrealistic. The vale 1.5 can be considered as a good estimator until a good proxy value is estimated.

- Based on the available data, the maximum number of infected cases in Sri Lanka, by 17 April would be 2460, if R_0 is 1.5.

- People should strictly follow the guidelines given by doctors. Those are simple measures to adopt which helps to prevent transmission significantly.

- The procedure of identification of suspicious COVID-19 cases should be expedited. If there is a shortage of officers to handle this, Government can take the service of other persons from other departments, cooperation's etc.

- Random checking is not efficient; you need to apply snowball sampling technique as practice now.

- Government should have immediately identified those who returned to Sri Lanka prior the given date without giving further extension.

- Government should take the service from other professionals as well.

- COVID-19 is not viable for Sri Lanka mainly due to very good system of mitigation methods we have been practicing and due to high temperature and high relative humidity. That could be the reason why the spread is less in dry zone and dry-intermediate zone.

- However, we cannot wait to start our normal work until the rate of spreading of COVID-19 becomes zero.

- Not allowing to travel between districts should be continued for some time, but some relaxation can be done within the district. Curfew can be released at different AGA Divisions within in a district at different time.

- In certain district government department and private sector can be allowed to work by imposing some conditions.

- Government should start a mechanism to get the views from other professionals and other officers irrespective of their level rather t_0 expedite the present work related to COVID-19.

- Universities can be reopened to academic staff and non-anemic staff as there are some academics who would like to work in the labs and give some significant contribution towards COVID-19.

- An efficient mechanism need to be implemented to buy fish, vegetables, fruits, and other essential items to all the families. Distributing free food items alone to poor people is not sufficient, as they may not have other cooking ingredients.

- Ministry of Health can upload all data related to COVID-19 on daily basis in a website so that others can use to do some research, particular to estimate R_0.

COVID-19 CURVE IN SRI LANKA WILL BE FLATTENING

22 1April 2020

https://epaper.dailynews.lk/Home/ShareArticle?OrgId=30747ed2&imageview=1
http://www.dailynews.lk/2020/04/22/features/216965/covid19-curve-sri-lanka-will-be-flattening

Extinction of COVID-19

Countries around the world are working to "flatten the curve" of new cases of Corona-virus pandemic. Flattening the curve involves with reducing the number of new cases and convergent to low constant value as the time passes. This helps the government and health authorities to prevent healthcare systems becoming overwhelmed.

The plot of daily new COVID-19 cases (11th March to 14th April) and five-day moving averages for the same period is shown in Figure 3.1.
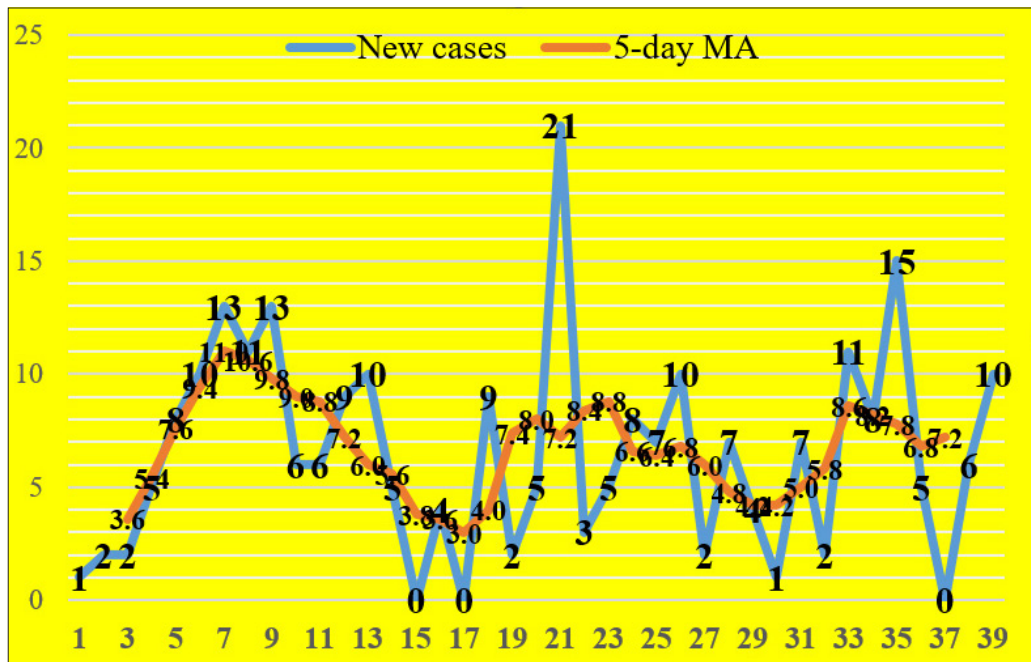
*Figure 3.1: Trend in Daily New Cases of COVID 19*
(11 March - 18 April)

During 11th March to 18th April, an exceptional value of 21 had been reported on 21st March, and this can be considered as influential points to the normal pattern. Of course, this trend could have been influenced by many external factors. To

reduce the noise (the effect of hidden variability of such factors), the trend was plotted for 5-day moving averages (MA). Obviously it showed a less variability. It has been fluctuated between 5 and 8 since later part of March. This pattern is an indication that the new cases are flattening in Sri Lanka. This is quite attributable to the effectiveness of control measures implemented by the government and the cooperation given by the people.

Modeling the % of Daily Increase of Cumulative COVID-19 Cases
The above flattening can be further justified by the trend of percentage increase in cumulative daily new cases (Figure 3.2).
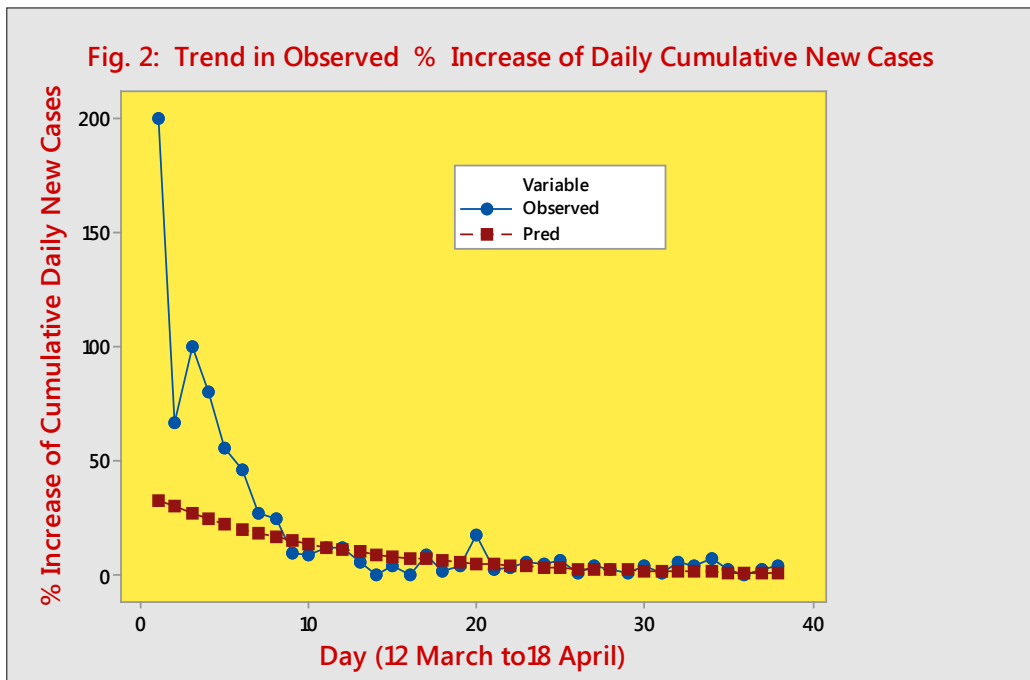
Figure 3.2: Trend in Observed % Increase of Daily Cumulative New Cases

It has a clear exponentially decreasing trend that can be modeled. The percentage increase of daily cumulative values varied from 200% to 50% at the very beginning, though the numbers were low. However, since the beginning of April 2020, the percentage increase varied from 1.7% to 4.2%. Although the model did not predict so well for the first few days, the fitted values were almost close to the observed values since the later part of March. Thus it can be expected the same trend of percentage increase in the next few weeks too. This would be a better indication for the flattening of daily trend in new COVID-19 cases.

Do We Need Massive Testing?
There are two schools of thought on the above subject among the Sri Lankans health professionals. Based on the observed data as of 12th April 2020 in Sri

Lanka and other countries (Table 3.1), my personal view is that we don't need to go for massive testing like in other countries.

Table 3.1: Percentage of Effectiveness of Sampling in Identification of COVID19 (as of 14th April 2020)

Country	Total		% of positive cases w.r.t to total tested	Population (Mln.)
	Positive Cases	Tested		
Australia	6,586	406,510	1.8	25,499,884
New Zealand	1431	83224	1.7	4,822,233
Taiwan	420	53,005	0.8	23,816,775
Sri Lanka	254	4,768	5.3	21,413,249
Singapore	6,588	94,796	4.5	5,850,342
South Korea	10,661	559,109	1.9	51,269,185

Of those countries affected with COVID-19, the population in Australia and Taiwan is similar to Sri Lanka. The population in Singapore is very low and in South Korea it is almost two times of Sri Lanka. All the other four countries have tested exceptionally higher number of samples than Sri Lanka. South Korea, Australia, Taiwan, New Zealand and Singapore have used new technological approaches to trace the contacts. However, the probability of identifying a COVID-19 case from a susceptible group of people in Sri Lanka is significantly higher (p=0.00) than the other countries.   It can be concluded with 95% confident that sampling methodology in Sri Lanka is significantly more effective than other five countries.

However, the number of cases tested in most affected countries such as USA, Germany, Italy, and Spain varied from 669,050 (USA) to 355,000 (Spain) and the probability of detecting a COVID-19 case among the susceptible individuals in those countries varied from 0.459% (in Spain) to 0.159% (in Italy). In fact, it should be noted that most of the highly affected counties started their testing procedures only after more people have become infected with COVID-19. In Sri Lanka it was started at the very beginning of the disease spread.

A minimum number of samples to be tested cannot be recommended precisely as the initial symptoms of COVID-19 is not possible to differentiate well. The present method of snowball type sampling is much

better (in terms of cost-effectiveness of detecting an infected individual) as the COVID-19 has not yet spread heavily across the country. However, The Indian Council of Medical Research (ICMR) has started random sampling method of all the symptomatic cases of COVID-19 at different levels, but it is a questionable move to many scientists.

Estimating R_O Based on Case Count Approach

Based on the local daily data available on the websites from 13th March to 6th April, I estimated R_0 value to be 0.51 [95% CI = (.47, 0.55)] by considering the number of Freely Moving Infected (FMI) cases and Currently Infected cases (CI). The main assumptions were: (a) each FMI case roams for 5 days and (b) the total number of CI cases was assumed as three times of the actually infected cases during that period.

On the same argument, I computed R_0 using data from 13th March to 12th April 2020, and from 13th March to 18th April it was found that R_0 to be 0.43 [95% CI = (0.40, 0.46)] and 0.38 [95% CI = (0.35, 0.41)] respectively. Thus it can be concluded that the rate of spreading COVID-19 in Sri Lanka is decreasing. This is a good indication to say that the spread of COVID-19 is decreasing with time in Sri Lanka, under present environment. Thus, it can be easily assumed that the probability of community transmission is almost zero.

Recommendations

- The trend in diagnosis of daily COVID-19 cases will be diminished down to the earth, presumably on early part of May.

- It contemplates that COVID-19 would not be an Epidemic in Sri Lanka.

- Detecting COVID-19 cases in Sri Lanka is very proactive.

- R_0 value has been decreasing with time.

- People should be susceptible to follow the "intra vires" instructions given by the health authorities even after the situation back to normal.

- The analysis inferred that probability of community transmission is almost zero.

Article 4

COVID-19 CURVE WILL BE FLATTENING BY MIDDLE OF MAY: GOOD NEWS FOR BUSINESS COMMUNITY

08 May 2020

*https://epaper.dailynews.lk/Home/ShareArticle?OrgId=c3a3112b&imageview=1*

Introduction

Countries around the world are working to "flatten the curve" of new cases of Coronavirus pandemic. As statistics and statistical models are very powerful tool in data driven decision making (DDDM), I derived inferences related to flattening of COVID-19 curve by analyzing data up to 05th May. DDDM involves making decisions that are backed up by inferences derived by statistical analyses of observed data rather than making decisions that are intuitive or based on observation alone.

During the period from 11th March to 05th May, the probability of getting less than or equal to 10 new confirmed cases per day is 0.64. The corresponding probability for more than 25 cases is 0.16. This was due to the observing more than 25 cases consecutively for seven days. Nevertheless, I believe it was an unusual phenomenon that happened against the natural course of the disease. In fact, this has been realized by the government appropriately and immediate remedial measures were taken by the government to avoid a resurgence. Those points are considered as influence points which impact to the natural pattern that we have been observing.

To reduce the noise, the trend was plotted for 5-day median (Figure 4.1). This is a better outlier resistant smoothing technique than 5-day moving averages. It can be seen that the median has been decreasing from 52 (25 April) to 27 (30 April) in spite of outliers. This pattern is an indication that the new cases are flattening in Sri Lanka. Thus, it can be concluded by middle of May curve will convergent to smaller number of cases.

Daily Trend of COVID-19 Cases
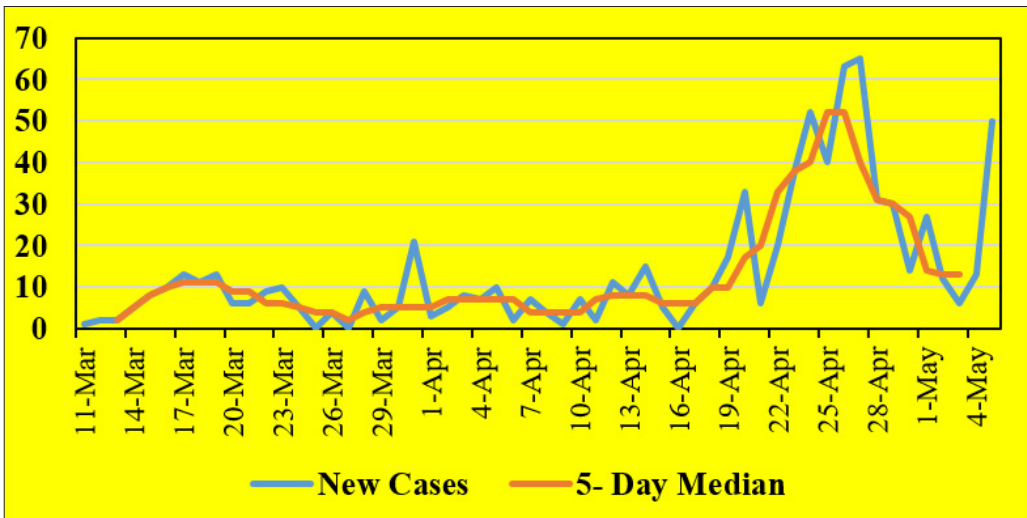
Figure 4.1: *Trend in Daily New COVID Cases and 5 - Day Median (11th March – 05th May)*

Trend in % Increase of Daily Cumulative COVID-19 Cases

Figure 4.2 has a clear exponentially decreasing trend and in fact most of percentage are very low (< 10%) in particularly as the time passes. That is also a clear indication of flattening the daily new cases of COVID-19.
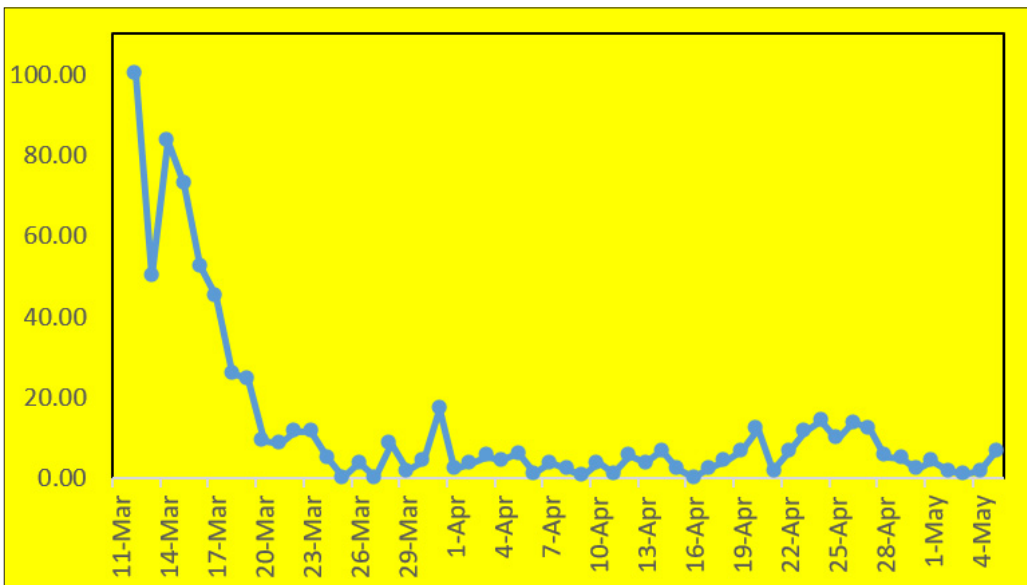
Figure 4.2: *% Increase of Cumulative Daily New Cases*

Recommendations

COVID-19 Curve in Sri Lanka will be flattening by middle of May. Government can relax various restriction so that business can start and people can come back to normal life. However, people should be susceptible to follow the "intra vires" instructions given by the health authorities even after the situation back to normal. Data driven decision making (DDDM) is a powerful tool for effective decision making.

Article 5

SRI LANKA'S COVID-19 TRAJECTORY: SUGGESTION FOR RECOVERY

11 May, 2020

http://epaper.dailynews.lk/Home/ShareArticle?OrgId=9e74db7e&imageview=1
http://www.dailynews.lk/2020/05/11/features/218279/suggestions-recovery

Extinction of COVID-19

Countries around the world are working to "flatten the curve" of new cases of Corona-virus pandemic. Flattening the curve means in reducing the daily number of new cases and those numbers need to be convergent to low constant value as the time passes. It helps to medical and public health professionals, administrators, policymakers, employers, and even community advocates to release lockdown and back the lives of our people normal. In this article I am deriving inferences on that aspect based on observed data in Sri Lanka and few other countries which will also help the government and health authorities to prevent healthcare systems becoming overwhelmed. This is second analysis which is a continuation of my previous article (*http://www dailynews .lk/2020/04/22/features/216965/covid19-curve-sri-lanka-will-be-flattening*).

Countries Flattening the COVID-19 Curve

As per 01st May, I noted that the COVID-19 curves of New Zealand, Australia, Hong Kong and Taiwan have been convergent to a smaller number depending on the country. The corresponding trends are shown below.

- In **New Zealand** total number of COVID-19 as at 01st May is 1485. The number of new cases has been exponentially decaying since 04th April and in fact it has been less than 20 since 28th March and in fact less than 20 since 12th April.

- In **Australia** total number of COVID-19 as at 01st May is 6780. The number of new cases has been exponentially decaying since 28th March and it has been less than 20 since 20th April.

- In **Hong Kong** total number of COVID-19 as at 01 May is 1040. The daily number of new cases has been less than 20 since 22nd March, and also it has been exponentially decaying too since 28th March.

- In **Taiwan** total number of COVID-19 is 432. Since 13th February, greater than 20 positive cases were found five days only. The number of COVID-19 cases has been decreasing sine 21st March and it has been less than 20 since 25th March and less than 10 since 01st April with an exceptional value of 22 cases on 19th April.
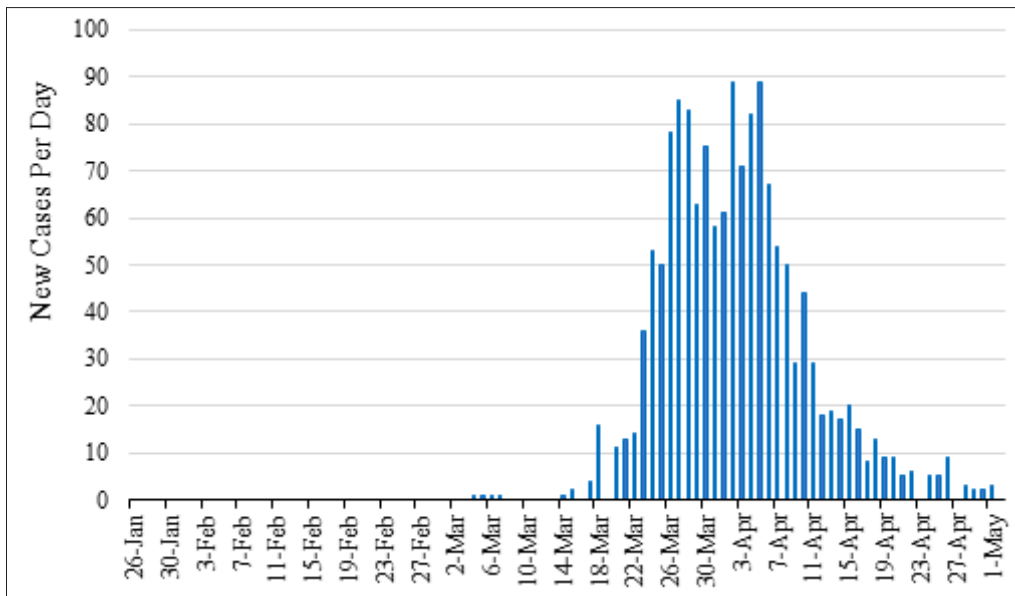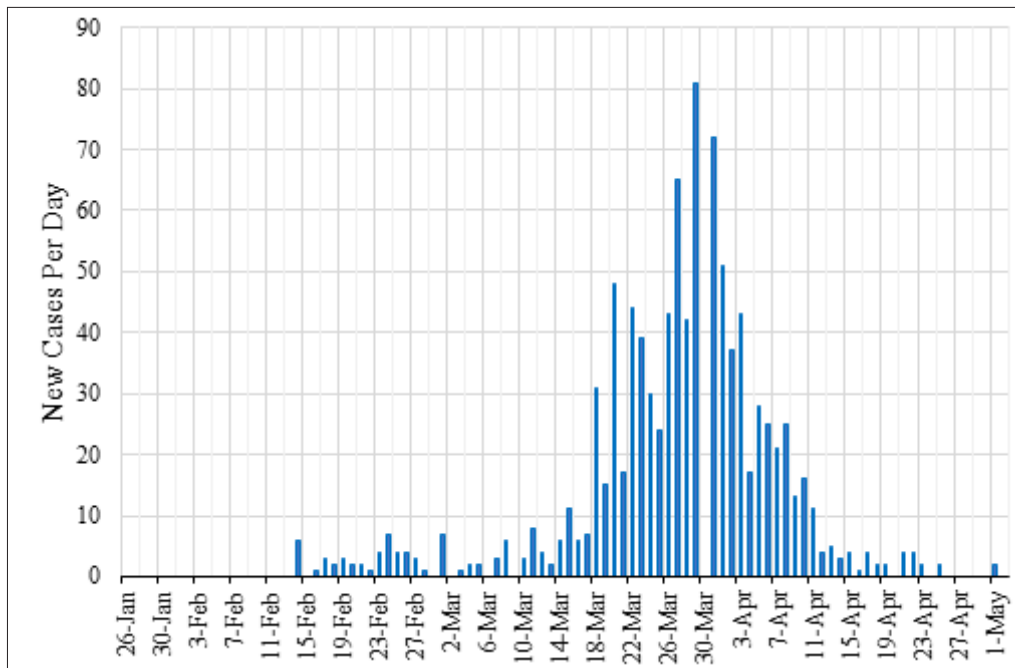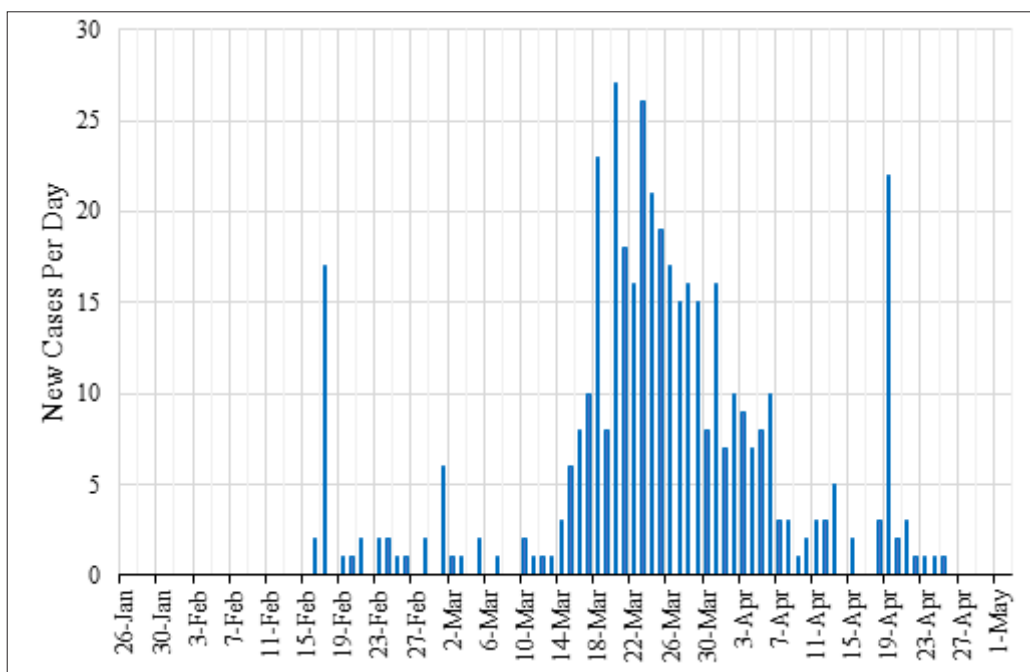

Figure 5.1: % New Zealand Daily New Cases
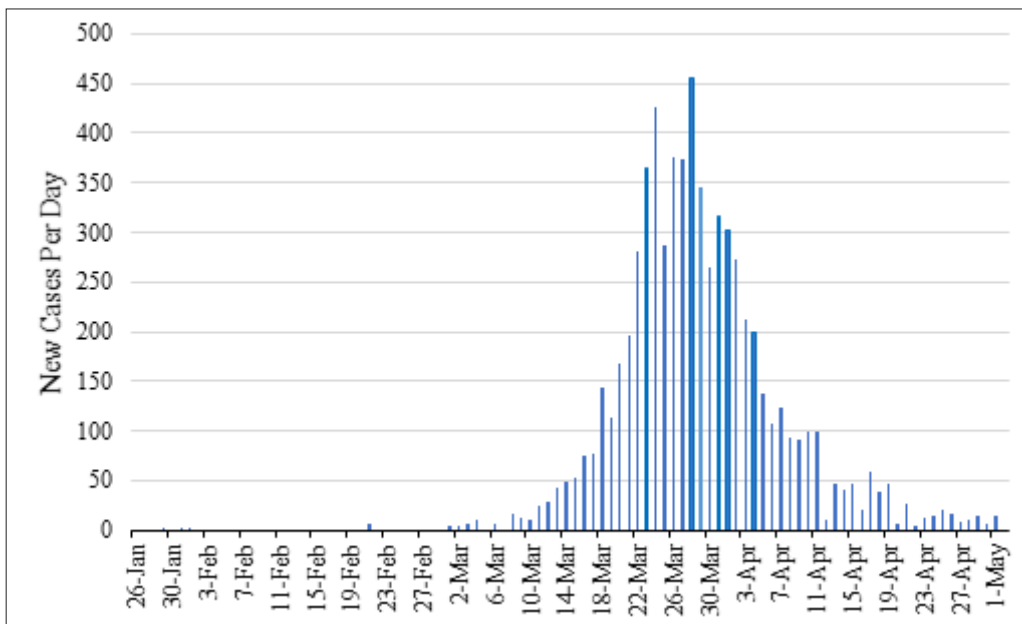
*Figure 5.2: Australia Daily New Cases*

Figure 5.3: **Hong Kong Daily New Cases**

*Figure 5.4:* **Taiwan Daily New Cases**

However, in Sri Lanka the pattern (Figure 5.5) has slightly deviated from the above patterns, but it can come back to that shape soon. During the period from 3rd March to 01st May 26 in Sri Lanka, the probability of getting less than or equals to 10 new cases per day is 0.65. The corresponding probability for more than 25 cases is 0.15. This was due to the observing more than 25 cases consecutively for six days which needs to think as an unusual phenomenon. In fact, this has been realized by the government and immediate remedial steps have been taken by the government to avoid such sudden spikes of recant positive cases. These points are considered as outliers (or influence points) which may impact to the normal pattern we have been observing. Thus we could expect a delay in few weeks in flattening the COVID-19 curve as shown by my previous article and the new period would be middle of May.
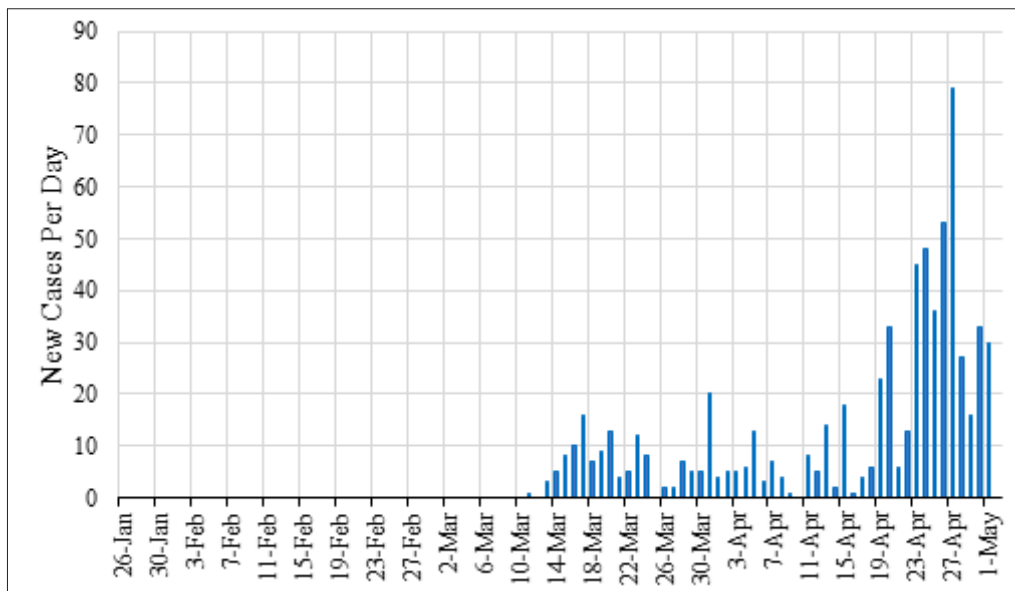
Figure 5.5: *Sri Lanka Daily New Cases*

Another Approach to Flattening the COVID-19 Curve
In spite of sudden spikes, the flattening the curve can be further justified by the trend of percentage increase in cumulative daily new cases (Figure 5.6).
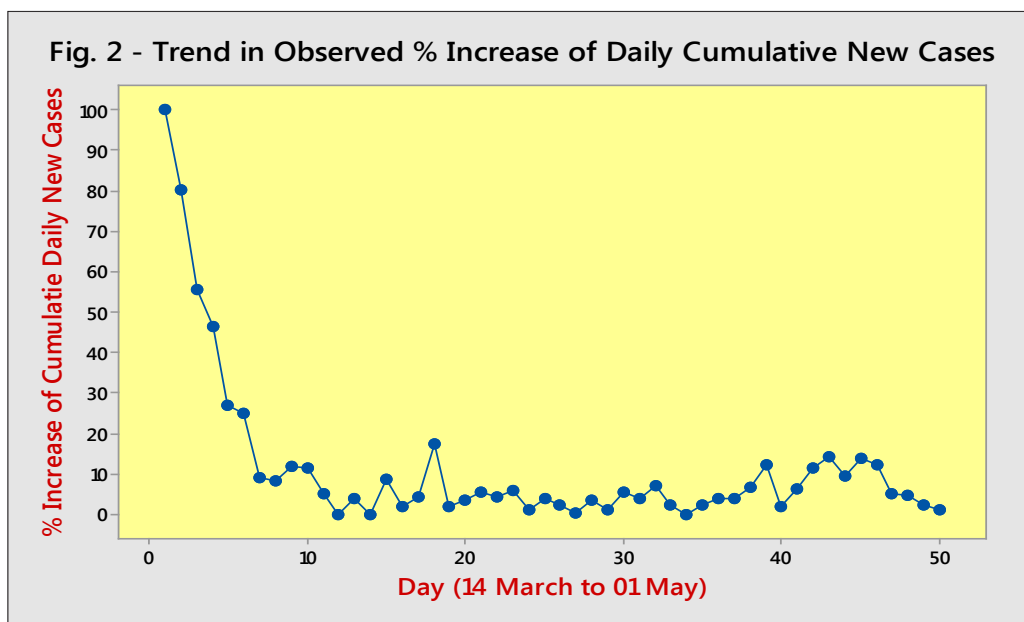
Figure 5.6: *Trend in Observed % Increase of Daily Cumulative New Cases*

Fig. 5.6 has a clear exponentially decreasing trend and in fact most of percentage are very low (< 10%) in particularly as time increases. Let the cumulative values of daily new cases on $(t-1)^{th}$ day and t^{th} day be y_{t-1} and y_t respectively. Then the percentage increase at time t is:

$$\frac{y_t - y_{t-1}}{y_{t-1}} * 100 = \left(\frac{y_t}{y_{t-1}} - 1\right) * 100.$$

Thus as the percentage value is very low, it can be concluded that cumulative value at time t tend to the cumulative value at time t-1, which is good indication of flattening the curve soon. Thus it can be concluded curve would be flattening in about 10 days' time.

Case Fatality Rate (CFR) and Recovery Rate (RR) as on 01st May
The number of COVID-19 cases are divided into active cases and closed cases in almost all world data bases on COVID-19. The closed cases are divided into two cases namely recovery and death. The active cases are divided in to mild condition and critical condition.

The CFR is the ratio between confirmed deaths and confirmed cases (COVID-19 cases). This is an indicator to compare the death rates in different outbreaks and also to compare the mortality rates in a given outbreak among countries. Generally, it is better to see the trend of CFR over time. Also this has to be related to demographic status of the patients. But as my intension was to compare CFR

in Sri Lanka with CFR values in other countries. I have selected few countries based on the severity of COVID-19 (Figure 5.7)
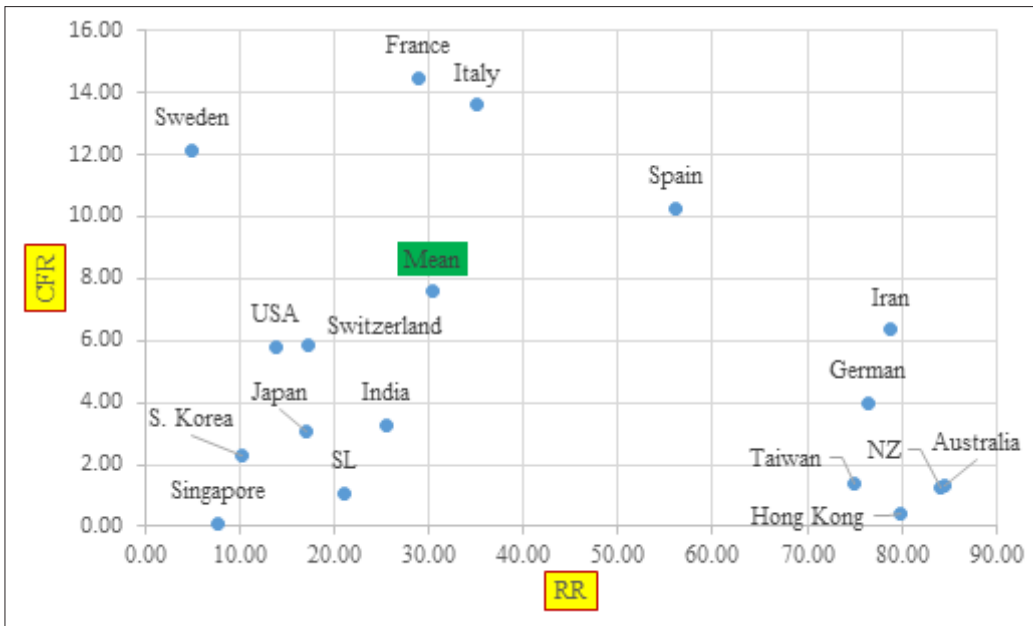
Figure 5.7: Comparison of CFR and RR in Different

It can be seen that four countries whose COVID-19 has been flattening, CFR is also very low and less than 2.0. The CFR is the lowest in Singapore (0.09) followed by Hong Kong (0.39). The CFR in Sri Lanka (1.08) is also below than the corresponding values of Australia (1.35) and New Zealand (1.29). The value of Sri Lanka confirm that we do not want fear too much for COVID-19. The CFR values are greater than 10 in Spain, Sweden, Italy and France, but higher than USA (6%). This is a plus point for our Health Ministry.

The recovery rate (RR) is defined as the ratio of recovery cases and deaths. Also it can be seen that recovery rate is the highest in Australia followed by New Zealand (> 80%). The RR in Hong Kong (80%) and in Taiwan (75%). However, in Sri Lanka RR is very low. In fact, it lower than the average value of RR of the selected countries I selected.

In fact, both CFR and RR need to be deeply studied and those should be related demography of patients. This analysis clearly indicates that the four countries NZ, Australia, Hong Kong and Taiwan have very low CFR and the very high RR and COVID curve in those four countries have already started flattening. No doubt that Sri Lanka will also come to that level very soon.

Estimating R_O Based on Case Count Approach

R_0 is an important quantify which tells the rate of spread of a virus by one patient. In other words, if R_0 is 2.5, then one person with the disease is expected to infect, on average, 2.5 others. Initially, various people in Sri Lanka assumed various values for R_0 which vary 1.5 to 3.5 and thus the results obtained were misleading the public as well as the decision makers.

Of course there can be various methods to estimate R_0 to our condition too, though the spread has not gone to community level. Using a simple Excel sheet, I estimated the number of Freely Moving Infected (FMI) cases and Currently Infected cases (CI). The main assumptions were: (a) each FMI case roams for 5 days and (b) the total number of CI cases was assumed as three times of the actually infected cases during that period. My proxy estimator for R_0 is the ratio between CI and FMI.

Table 5.1: Estimated R_0 values in different time periods

Period	R_0 Value	95% CI
13th March to 6th April	0.51	[0.47- 0.55]
13th March – 12thApril	0.43	[0.40 – 0.46]
13th March – 18thApril	0.38	[0.35 - 0.41]
13th March – 30th April	0.36	[0.33 - 0.39]

Thus it can be concluded that the rate of spreading COVID-19 in Sri Lanka has been decreasing with time. The R_0 below 1 suggests that the number of cases is shrinking, possibly allowing societies to move open back up. An R_0 above 1 indicates that the number of cases is growing, perhaps necessitating renewed lockdowns or other measures.

This is a good indication to say that the spread of COVID-19 is decreasing with time in Sri Lanka, under present environment. Thus, it can be easily assumed that the probability of community transmission of COVID-19 is almost zero.

Conclusions

- COVID-19 curve in Sri Lanka will be flattening by middle May.

- Case Fertile Rate is very low in Sri Lanka.

- Recovery rate is also low which we need to worry.

- The probability of community transmission is almost zero. Government can relax various restriction so that people can come back to normal life at least with in a district.

- People should be susceptible to follow the "intra vires" instructions given by the health authorities even after the situation back to normal.

- It is important to study demographic data of the COVID-19 cases

Article 6

CAN WE RELAX SOCIAL DISTANCING? A CRITIQUE BASED ON COVID-19 DATA IN SRI LANKA

23, June 2020

Perhaps Sri Lanka has now reached the phase-5 of the COVID-19 outbreak in which the number of cases are expected to decline. This is quite evident from the fact that we do not get newly infected cases from the community other than from NAVY pocket and the imported cases (the infected people who return from overseas). Therefore, we do not want to fear that the COVID-19 will recur and could generate a situation like in other countries such as USA, UK, Brazil, or India because we have maintained extreme precautions to prevent the disease in the community.

In fact, I predicted that COVID-19 curve in Sri Lanka will be flattering by middle of May. I also pointed out that based on estimated the rate of spreading COVID-19 by a single infected person, the chance of spreading COVID-19 at community level in SL is almost zero. In fact, it was proven correctly (08th May and 11th May Daily News).

Therefore, it is my strong belief, that we must practice data driven decision making (DDDM) as far as we can, in order to achieve the best possible outcomes in both socio-economic and health terms. Of course, we need to understand that all decision may not be perfect, but it is our responsibility to make judgements based on scientific evidence.

Over the last 3 weeks we hardly observed a new COVID-19 case apart from the Navy group and the infected people coming to SL from different parts of the world.

This fact has provided enough evidence to assume that the transmission of the disease has been under control, even when we have released lockdowns partially. Nevertheless, the health system of Sri Lanka is deemed to have handled the disease outbreak well in a local context although it may not be sufficiently resourced for a huge surge of patients at a given point of time.

Thus, I am very confident that we do not get a large spread of COVID-19 under the prevailing conditions in Sri Lanka.

COVID-19 is a new disease and therefore limited information is available with regards to its risk factors and the severity. Based on currently available information and clinical expertise, elders and people with serious underlying medical conditions are at higher risk of a severe form of illness from COVID-19. In fact, the case specific morality rate in Sri Lanka has been among the lowest compared to other countries.

We have decided to go for the general elections, though it is late. That is good. So why should we fear? Neither the health authorities nor the statisticians can assure that there will be no COVID-19 person for sure (100%) in the foreseeable future. The main advises given by the health authorities to reduce the spread of COVID-19 are: social (physical) distancing, wearing face masks and washing hands.

Social Distancing
To practice social or physical distancing one should stay at least 3 feet (about 2 arms' length) from another as shown below.
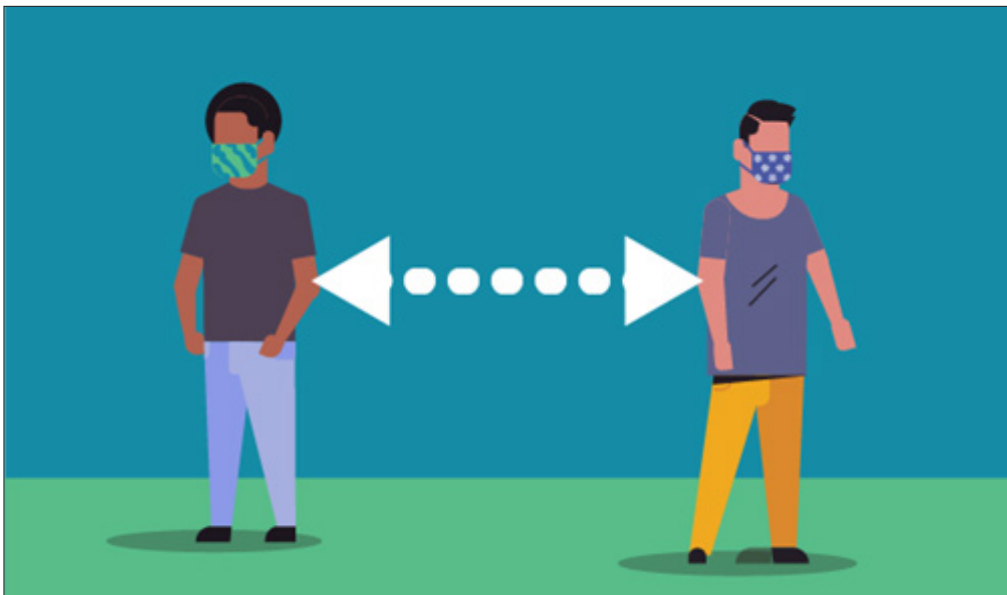
The flattening curve of COVID-19 in Sri Lanka is similar to that of New Zealand by middle of May. Inclusion of positive cases reported from Navy pocket and people who are returning from other parts of the world is not correct as they do not reflect the detection from the general public. If we exclude those from our database, the COVID-19 curve in Sri Lanka, is far better than the New Zealand. New Zealand has now ignored social distancing and has opened the country for normal functions. In fact, they have even started rugby matches from 14 June 2020.

- If you go to banks, supermarkets, government offices, pharmacies, shops etc. you will find how difficult to maintain social distancing. Only thing you could do is to stay in a queue with a physical distance from another.

- When it is allowed two persons in a motorcycle, 3 persons in a three wheeler, 4 persons in a car, 7 persons in a jeep (deepening on the seats), and more people in a van (depending on the number of seats) no social distancing is practiced. In public transport such as buses and trains, one could hardly maintain social distancing.

- When group discussions and interviews are being held, when foods are distributed by various agencies, in press conferences, and in many events in TV we do not see social distancing much.

- If we visit a doctor no social distance is maintained there too.

- We had lock downs, we maintained social distancing, we wore and wear face masks, and we wash our hands as routine habits.

- Moreover, social distancing is difficult to maintain in many parts of the country as the distance between many houses of poor people are less than one meter. Two or three people sleep together in a small single room in some houses. All of them go to work in different places and come back home in the evening.

- When you go to fish market, vegetable market, no social distancing is maintained.

- Though some people stayed at home during initial lockdown, majority of them did not maintain the distance among people within the house or between houses. Of course, it is quite natural to occur as people have complex social behaviors.

- People living together in close quarters, or share a small apartment, when people live in the same household with large or extended families it is quite impossible to maintain social distancing.

Face Masks

- Wearing face mask was not practiced properly. However, wearing face mask may have many problems. There are various views from the medical professions in reference of wearing face masks in different parts of the world. Situation is same in Sri Lanka too. In practice, it may not possible to wear a face mask for a long period when someone is working.

- Doctors have also advised not to wear face mask in certain events such as jogging, exercising etc. as long as you keep the distance. Even when

driving in an air-conditioned vehicles it is not possible to wear face masks if the driver use spectacles. Further, even for a normal person it is not possible to wear it for a long period.

Washing Hands

- Washing hands is not practiced often, because most people have no access for water and soap when they are away from their home or workplace (e.g. traveling in a bus).

- People in many parts of the country have no water even to drink.

- As an alternative, if the hand sanitizers are used, how can a poor person afford them continuously? Even, in most of pharmacies, shops this is not practiced.

Therefore, I wish to make following suggestions to expedite the social and economic recovery of the country while sustaining the prevailing control situation of COVID-19 outbreak.

Recommendations

- No, need to spend large amount of money for rehearsals of election polling and also during elections, apart from normal activities as we used to practice. Generally, even in a normal election day, people used to walk in a queue slowly without disturbing to each other.

- Eating food from hotels and restaurant can be allowed as we practiced past.

- If in house, people work in different places and come back home in the afternoon and stay together, may be 4 or 5 in a small room. So why 2-3 university students can't can stay in a hostel depending on the size?

- Tuition classes can be started.

- Post graduate courses in the both public and private universities can easily be started.

- Most of other activities such as barber shops, beauty parlors, etc. can be allowed to start as normal.

- Most of private sector can be allowed to start their actives as they practiced.

- Gathering people in form of public rallies can be controlled.

DO WE HAVE TO FEAR OF A SECOND WAVE OF COVID-19 IN SRI LANKA: BASED ON DATA DRIVEN DECISION MAKING (DDDM)


13, July 2020

The new corona-virus has been rapidly spreading across the globe since early February, 2020. The spread of the virus has been significantly different among the countries with respect to the number of cases and case specific fatality rates. Social behavior, climate factors and lockdown measures that considered to be determinants of the spread of the disease are also varied among the countries. Consequently, the trends in COVID-19 curve too significantly vary among the countries. While this curve has not been flattening in many countries, scientists are expressing their concerns over a second wave of COVID-19. As per the prevailing status most of the countries are still in the
"first wave" of COVID-19 outbreak.

The idea of a second wave has come from the flawed comparison with the seasonality of the flu virus. Early in the pandemic, many experts discussed the similarities between SARS and COVID-19, and from these similarities, it was tempting to assume that COVID-19 would behave similar to a flu pandemic. A second wave refers to an outbreak situation where the cases tend to get increase with time once the initial outbreak curve has shown a clear flattening.

Thus we need to look at the trend in the first curve to justify the second wave. We need to take decision based on our data, not by observing the other countries. Unnecessary fear of a second wave should not be allowed to get socialized unless there is scientific evidence. Therefore, according to my observations people in Sri Lanka should not fear that the COVID-19 would generate a situation like in USA, China, UK, Brazil, or India, provided that we honor the health advices.

Of course no one can predict for sure (100% accurately) that the chance of emerging a second outbreak is zero. In fact, based on data driven decision making (DDDM), I predicted that COVID-19 curve in Sri Lanka will be flattening by middle of May. Also I estimated the rate of spreading COVID-19 by a single infected person is less than one and claimed that the chance of spreading the disease at community level is almost zero (08th May and 11th May Daily News).

Over the last 70 days we hardly observed a new COVID-19 case apart from the two clusters in Navy camp and Kandakadu Drug Rehabilitation centre. Apart from them we have been receiving infected Sri Lankans who arrive from overseas. This fact has provided enough evidence to assume that the transmission of the disease has been under control, even when we have released lock-downs partially. Of course, it is a true fact that all the people in Sri Lanka did not follow all the guidelines 100% during lock-down period from 13 March to date. Unfortunately, no study has been carried out to obtain a better estimator.
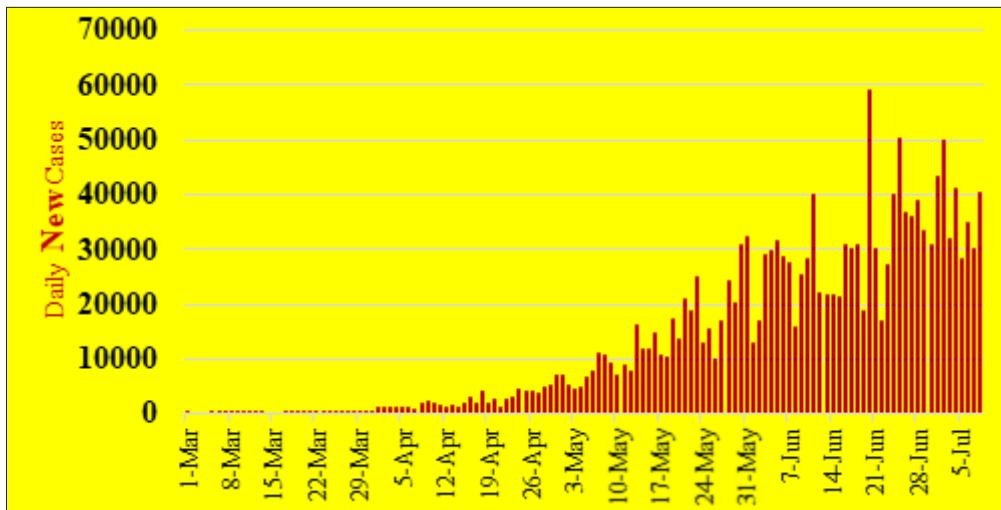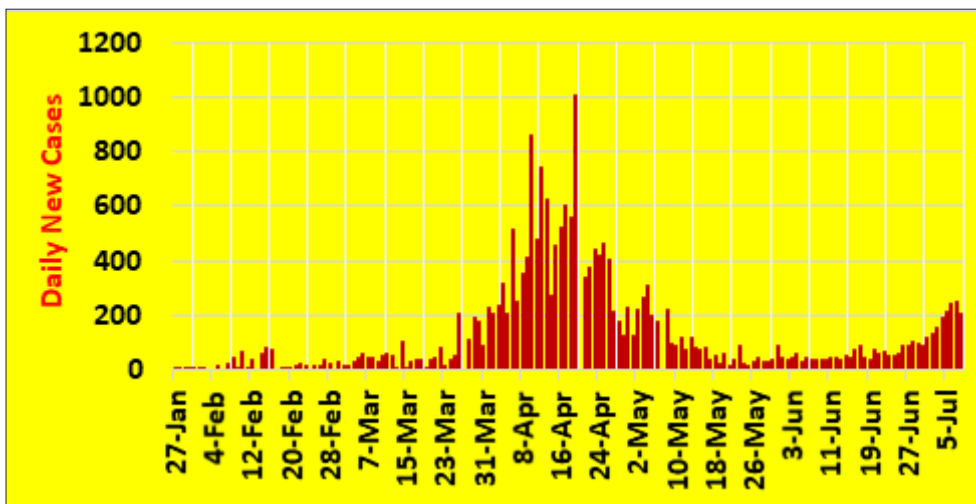

Figure 7.1: **Daily Trend in Brazil**

The trend in Brazil (Figure 7.1) has been still increasing and it is still in the stage of first wave of COVID-19.
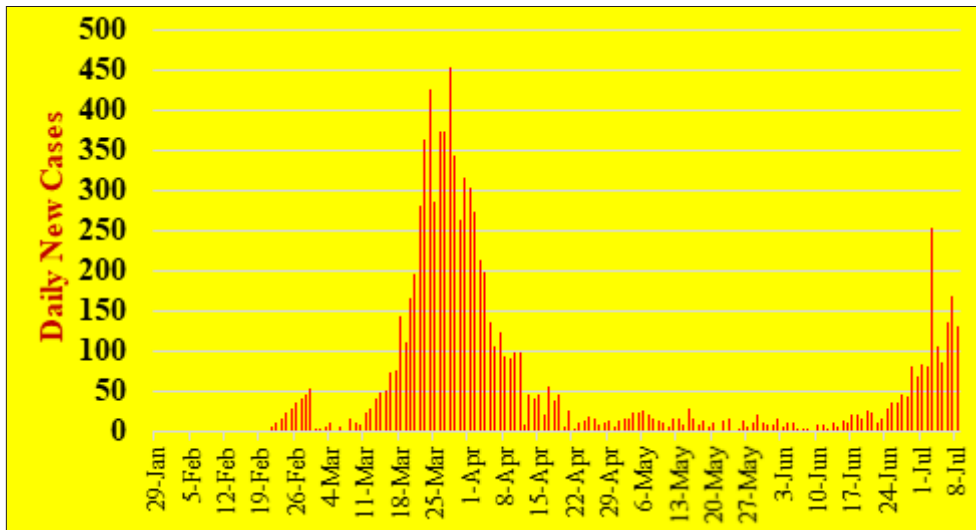
Figure 7.2: **Daily Trend in Australia**

Figure 7.3: **Daily Trend in Japan**

The trends in Australia (Figure 7.2) and Japan (Figure 7.3) show an increase after a clear decline in the first curve of the outbreak. This can be considered as a 'second wave of COVID-19'. However, in Australia, the numbers are lower than that in Japan. It has taken 35 days to start the second wave in Australia and the corresponding period is 30 days in Japan.
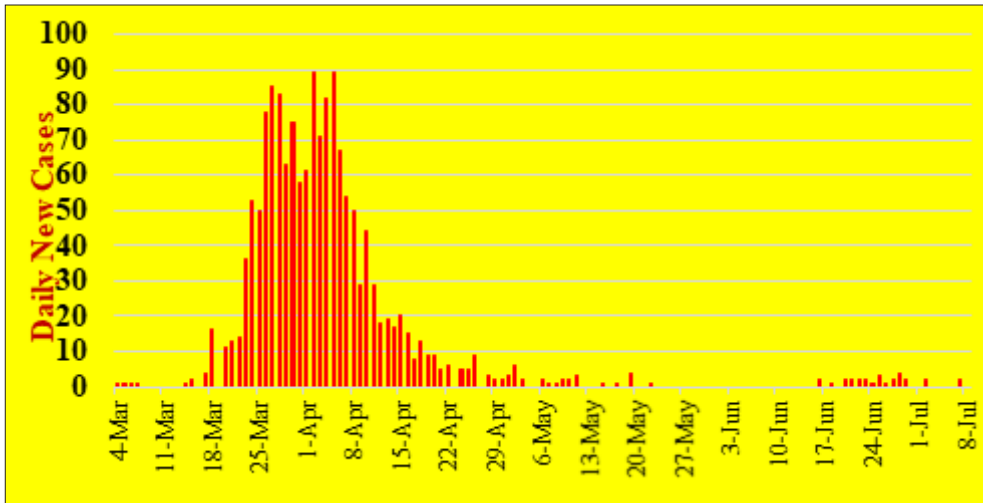
Figure 7.4: Daily Trend in New Zealand
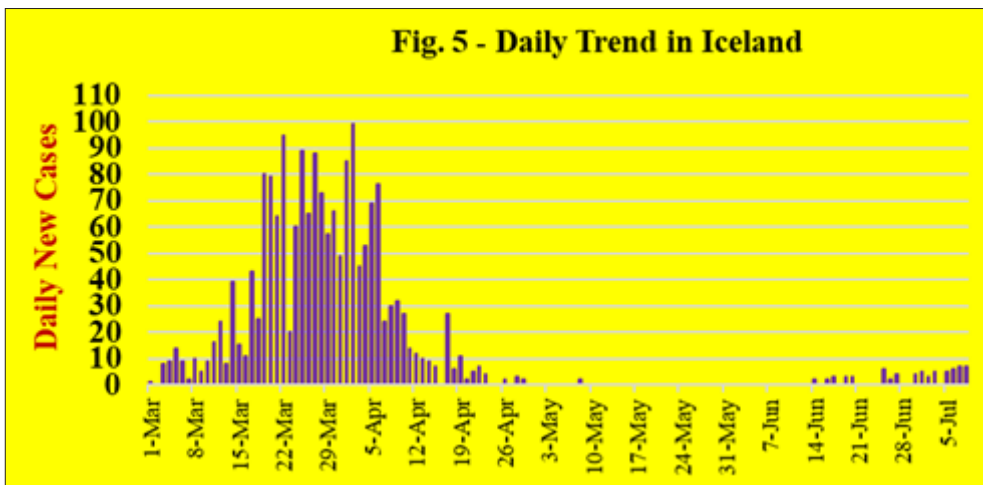
Figure 7.5: Daily Trend in Iceland

By combining various public health approaches and behavioral control of people, countries like New Zealand, Sri Lanka and Iceland have almost halted the virus. In New Zealand, the daily COVID-19 has been less than 4 since 3rd May, and in Iceland (IC) it is less than 7 since 23rd April with an exception of 7 for 2 days. In Sri Lanka we did not find a single COVID-19 case from the community since 18th May with an exception on 8th July. The distributions of daily COVID-19 cases in those three countries after the dates given above, are shown in Figure 7.6.
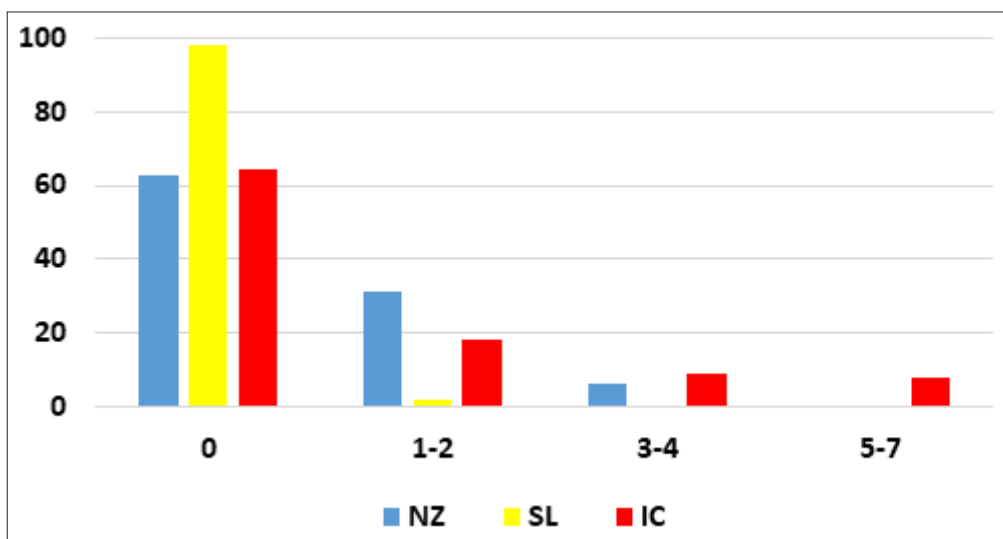
Figure 7.6: *Percentage Distribution of the New COVID-19 Cases after Starting Flattening Curve*

The probability of zero occurrence per day in SL is 98% since 18th May. The corresponding probabilities in NZ is 63% since 3rd May and 64% in IC since 23rd April. Of those three countries Sri Lanka has been performing better with respect to preventing a resurgence of a second wave of COVID-19 in the community.

For the virus to spread, it requires a susceptible individual and an infected host in close contact. These factors are conveniently captured by the value of R_0, which is defined as the average number of new cases caused by one infected individual. In Sri Lanka, under present circumstances, this value is less than 1, confirming that the chance of a second wave is very low.

Although it is claimed that we need to do about 3,000 - 4,000 PCR tests per day, as an applied statistician I totally disagree on that. It has to be designed scientifically in consultation with an experience applied statistician. However, it should be noted, even if you do PCR to all citizens and found no one positive, it does not guarantee that there is no COVID-19 patient in Sri Lanka, as the rate of success in PCR test is not 100%.

A second wave of COVID-19 is likely to depend on our capability and the effectiveness of getting these blips of infection, which we will invariably get, controlled within our system. Although we may have certain constraints in resources, we have been successful in case identification, isolation and contact tracing etc. Thus it is my opinion that we do not want to fear of a second outbreak provided that we maintain social discipline and hygienic practices.

Many people have lost their jobs. Some are getting less than the amount they used to get. Some private companies pay less salaries. But, at the same time government departments (including doctors etc.) earn more than they used to get because they get the full salary without any cost (or less cost) for traveling, clothing, food etc. as most of them are at home or doing on line work.

Recommendations for Decision Makers / Business Persons / Others

- No need to fear for second wave on COVID-19.
- Undue fear of a second wave can affect the normalizing process of the community
- Allow the foreigners to come and invest in Sri Lanka and they should be convinced not to fear for second attack of COVID-19.
- Schools and universities can be opened as normal way, without delay
- Permission should be given to start all categories of work irrespective of the type of work. Provided they wear face mask and practice hand hygiene.
- Factories and private companies should be allowed to start in full capacity.
- No need to carry out 3000 - 4000 PCR tests per day randomly
- Eating place can be allowed as normal.
- Public rallies can be controlled if they are very closed.
- No need a special regulation for election purpose.
- Second cluster identified in Kandakadu Centre has no impact on second wave.
- All the stakeholders (i.e. politicians, unions, media, health authorities, students and citizens) should behave responsibly in delivering messages to the community with respect to the COVID-19 situation in Sri Lanka.