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Use of Proxy Indicators to Interpret the Epi Curve of COVID-19 in Sri Lanka

IM Karunathilake[1], WMPC Weerasinghe[2], R. Rupasinghe[1], MC Weerasinghe[1]

[1]Faculty of Medicine, University of Colombo; [2] Ministry of Health, Sri Lanka.

* Correspondence: indika@medarc.cmb.ac.lk https://orcid.org/0000-0001-9772-116X

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Abstract

Sri Lanka has taken measures to avoid the introduction and spread of COVID-19 well before the country confirmed its first COVID 19 case on 27th January 2020, on top of its detailed epidemiological surveillance and infectious disease control system. Traditional indicators such as the daily case numbers have been used as an indicator to keep track of the outbreak progression. However, as the pandemic continued, the need to have proxy indicators was felt, both to better understand its behavior as well as future trends. The objective of this study was to explore the use of proxy indicators, namely the observed test positivity rate (TPR) and the mobility trends against the epidemic curve to interpret the behavior of the COVID-19 pandemic; their usefulness, and limitations. The information for the study was gathered using the COVID-19 daily status reports published and made publicly available by the Sri Lankan health authorities for the duration of 01/04/2021 to 30/06/2021. Trends of change of mobility during the period are gathered using regularly updated Google Community Mobility Reports. It is seen that the 'trend' of cases as depicted by weekly Observed TPR carries better information for decision making and evaluation of the methods to contain COVID 19 than using traditional proxy indicators such as the daily case numbers. The reported numbers in cases can be less than the actual numbers due to non-detection of cases in the community, under-reporting, delays in reporting, and PCR backlog. Trends of mobility changes and the trends of observed TPR together can be used to monitor and evaluate the effectiveness of the use of lockdown measures to contain the disease. It is recommended to adopt the use of such proxy indicators both in measuring the disease severity and the evaluation of the use of travel restrictions to contain the disease cost-effectively in a resource-limited setting.

Key words: COVID-19, Observed test positivity rate (TPR), Google Community Mobility Reports, Proxy Indicators, Weekly-Moving Average, Time Series Analysis

Sri Lanka has taken measures to avoid the introduction and spread of COVID-19 well before the country confirmed its first COVID 19 case on 27th January 2020, in a Chinese national visiting the island. The first locally acquired case of the disease was confirmed on 11th March 2020. Since then, Sri Lanka has reported 264057 COVID 19 cases and 3191 deaths as of 04/07/2021 as reported by the country's Epidemiology Unit and run under the Ministry of Health and published by the Health Promotion Bureau: the main authorities responsible for statistics of the pandemic and public awareness respectively (Health Promotion Bureau - Ministry of Health Sri Lanka, 2121). The country has taken multiple measures at multiple times to control disease transmission, including imposing of police curfew, strict travel restrictions, vaccination programmes, health promotion, and awareness campaigns to improve public compliance as well as improving the health infrastructure to raise the demands of the increasing number of cases (Karunathilake et al., 2020).

The disease was well contained by early April 2021, but this success was followed by an increasing incidence of COVID 19 cases followed by deaths in the country beginning from Mid- April 2021, in the aftermath of New Year Celebrations. By 3rd July of 2021, 162,205 COVID-19 cases were reported during the recent outbreak according to official statistics (Epidemiology Unit - Ministry of Health, 2021b).

A well-established system of communicable disease surveillance was already in place in the country before the COVID 19 pandemic, which formed the basis in COVID-related data reporting (Amaratunga et al., 2020; Sadeeka Adikari et al., 2020) .

The timely and orderly reporting of COVID 19 related statistics helps gain insight towards decision making in control of transmission, reduction of mortality through identification of vulnerable groups, and evaluation of the productivity of the decisions taken for control of the disease.

However, the officially published data may not represent the actual real-time COVID-19 status of the country due to inherent factors of the disease such as the incubation period of the disease and the natural history of the disease progression as well as due to others such as delay in the presentation of asymptomatic cases, delay in reporting of confirmed COVID 19 cases and deaths, PCR backlog, etc. (Weerasinghe et al., 2020). The unavailability of real-time data can affect predictions and forecasts other than the process of pandemic management and resource allocation (Sarnaglia et al., 2021).

In this study, the use of proxy indicators to interpret the behaviour of the COVID-19 pandemic; their usefulness and limitations are discussed. The proxy indicators used in this study are the observed test positivity rate (TPR) and the mobility trends against the epidemic curve in the context of the pandemic in Sri Lanka during the period of 1st April 2021 to 30th June 2021.

2. Method

The information used here is gathered using the COVID-19 daily status reports published by the Epidemiology Unit (Epidemiology Unit - Ministry of Health, 2021a) and the Health Promotion Bureau (HPB, 2020) for the number of newly identified cases and Polymerase Chain Reaction (PCR) tests done per day respectively. The reports provided by these authorities for the duration of 01/04/2021 to 30/06/2021 were used. All these reports are publicly available through the official websites run by these two government agencies. Trends of change of mobility during the period are gathered using regularly updated Google Community Mobility Reports available freely (Google, 2021). The baseline of these mobility components is calculated by Google based on the median mobility of a community considering data for the 5-week period from 03/01/2020 to 06/02/2020 when the effect of COVID 19 was on mobility was negligible.

The study period includes a period of 2 weeks before the recent outbreak of COVID 19 in Sri Lanka, the initiation of the recent most outbreak following the New Year celebrations of the country, a period of strict travel restrictions, and the immediate aftermath of these restrictions. This allows studying the behaviour of the proxy indicators discussed in different phases of the epidemic.

In Sri Lanka, a confirmed case of COVID-19 is considered as a patient with a laboratory-confirmed COVID infection regardless of the presence or absence of the symptoms. The laboratory tests currently used to confirm the disease are the Reverse Transcription Polymerase Chain Reaction (RT-PCR) test for Severe Acute Respiratory Syndrome coronavirus 2 (SARS-CoV2 virus) and the Rapid Antigen Test for the same virus.

Sri Lanka currently relays the community COVID-related data through its 352 Medical Officers of Health while the hospital-based COVID-related data is fed to the system via hospitals and laboratories both in the state and private sector. This data is relayed to the regional epidemiologist and the Epidemiology Unit, from where data is relayed to the State Intelligence Services and also utilized for hospital allocation and decision-making purposes by the designated personnel.

The limitations in this system are delays in relaying data from the primary data sources, differences in reporting formats used by different regions, information from all laboratories, and all samples not reaching the upper levels of the system, etc. Similarly, delays in PCR reports and their backlog, delaying death reporting, etc., can be seen. The fragmented nature and the lack of sharing of data regarding hospital allocation, division of hospital beds, the numbers managed through home-based management, Intensive Care Unit utilization, and Oxygen need of patients are not included in this system and hinders interpretation and decision making regarding the current COVID status in the country for researchers interested in prediction modeling. However, some of those data were displayed in some of the dashboards maintained by independent organizations. This data is relayed through a separate data flow system, increasing the workload of the personnel involved in this data management system; duplication of data and raises issues of quality of data.

Proxy indicators are used to interpret and predict the behaviour of a pandemic when a single indicator does not meet the capability to predict the disease behaviour on its own.

In this study, the observed test positivity rate (TPR) and the trends of mobility changes are studied against the epidemic curve.

The Observed TPR was calculated as weekly average by dividing the number of cases confirmed on a given week by the number of PCRs done during the same period and converting it to a percentage value. Positivity ratio can be calculated as a moving average for 7 or 14 days (CDC, 2020).

$$Observed\ TPR = \left(\frac{No.of\ Covid\ 19\ cases\ confirmed\ during\ week\ x}{No.of\ PCR\ tests\ done\ during\ week\ x}\right) \times 100\%$$

The mobility indicators used are change of mobility at retail and recreational spots, grocery and pharmacy, and use of transit stations, workplaces, and residences. Transit stations include taxi/bus stands, railway stations, highway rest stops, car rental agencies, and ports. According to research done by Wijesekara et al. (2021) this mobility data can be used as a proxy indicator of the general movement pattern in the country.

Table 1: Proxy Indicators used in the study

Proxy indicators used in the study
Observed Test Positivity Rate (Observed TPR)
Mobility changes – retail and recreational spots
Mobility changes – grocery and pharmacy use
Mobility changes – transit stations
Mobility changes – workplaces
Mobility changes - Residences

The use of proxy indicators to overcome the inherent limitations in COVID related data and those limitations due to the multiple systems of data flow in the country and their utilization in the interpretation of COVID status and evaluation of measures taken to contain the disease is discussed in this study.

Results

Figure 1 shows the incidence of COVID-19 cases during the period of the study, as daily new cases and as average weekly new cases. These diagrams represent the change of the behaviour of the pandemic just before the third wave of Sri Lanka, supposedly started after the New Year celebrations in mid-April; behaviour in the initial periods of the third wave and following imposing strict travel restrictions within the island starting from 21st May 2021 to 21st June 2021 and the aftermath.

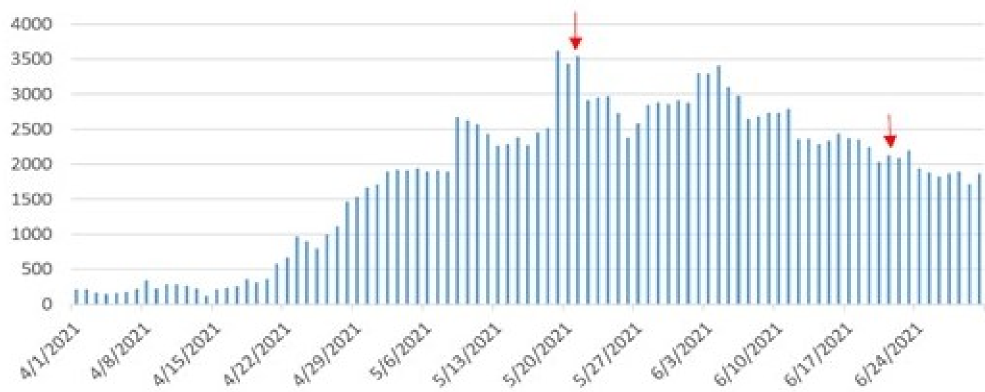


Figure 1.1 Daily New Cases

Figure 1.2 Average Weekly New cases

Figure 1 Distribution of COVID-19 Cases

Notes: Red arrows indicate the beginning and the end of the period of travel restrictions.

The epidemic curve alone does not describe the real-time situation of the pandemic due to several reasons. Among these is the inherent gap between the infection, patient presentation, and confirmation of the disease. The cases confirmed on a particular day, therefore, gives insight regarding the actual situation prevailing in the country, a few days before the actual date of confirmation. This delay causes difficulty in interpreting the beginning of an outbreak and the ending of one as the first day of the wave is actually not the first day of its beginning, and by then, the newly confirmed cases can already have infected others in their community. The change in the number of PCRs during the said period is as shown in Figure 2.

Figure 2.1 Daily PCR Tests

Figure 2.2 Average Weekly PCR Tests

Figure 2 Distribution of COVID-19 PCR Tests

Notes: Red arrows indicate the beginning and the end of the period of travel restrictions.

As shown here, the number of PCRs had been comparatively low during the pre-third wave period of the country, with peaking in the initial stage of the third wave. However, data regarding the exact number of exit PCRs, PCRs done on first contacts, and random sampling is not readily available to the public. The exit PCR does not adequately represent the community spread as those are done for individuals already in quarantine for 10-14 days.

Disaggregate data on PCR testing is not readily available at any level of the data flow. The Weekly Average Observed Test Positivity Rate of the PCRs done during the period of the study is given in Figure 3.

Observed TPR is calculated by dividing the number of newly identified cases by the number of PCRs, done on that particular day and converting to its percentage. The numerator and denominator do not have a true direct relationship as the cases reported on a given day are not reported solely using the test results of PCRs done on the same day due to PCR backlog resulting from capacity limitations in the country. However, this can be taken as a reasonable proxy indicator to observe disease activity when the weekly moving averages are considered as PCR test report delays of about 5 to 7 days had occurred at times.

Figure 3 Distribution of Observed Test Positivity Rate (TPR)

Notes: Red arrows indicate the beginning and the end of the period of travel restrictions.

Vong and Kakkar (2020) introduced the 3-step analysis based on TPR to monitor COVID 19 in communities with limited capacity for testing (Vong & Kakkar, 2020).

The first step involves the illustration of the relationship of the seven-day moving averages of Observed TPR and PCR tests done to the epidemic curve. In the second step, we assess the relationship of 7 days moving average of TPR, the cumulative number of COVID 19 cases, and the cumulative number of PCRs done during the given period. The third step is used to describe the relation of the Observed TPR and adjusted TPR to the epidemic curve during a given period.

Table 2 : Three Step Analysis Suggested by Vong and Kakkar

Step	Assessment
Step 1	Observed TPR (7-day moving average); tests done (7-day moving average); cases reported (epidemic curve)
Step 2	Observed TPR (7-day moving average); tests done (cumulative); cases reported (cumulative).
Step 3	Observed TPR (7-day moving average); adjusted TPR (7-day moving average); cases reported (epidemic curve).

Figure 4: Relationship of Observed TPR (7-day moving average), PCR tests (7-day moving average) to the epidemic curve.

Applying the first step of Vong and Kakkar's 3-step analysis to Sri Lanka's situation in the study period yields Figure 4 that depicts the relationship between the Observed TPR (7-day moving averages), tests done (7-day moving averages), and the epidemic curve.

The observed TPR mirrors the epidemic curve for the given period depicting that Observed TPR can be used as a proxy indicator regarding the disease activity in the community.

Using moving 7-day averages is a better proxy indicator depicting the trends of disease activity (Figures 1.2, 2.2, and 3) rather than standalone values as shown in the above graphs (Figures 1.1, 2.1, and 3).

This further shows that the peak of the average PCR was followed by the peak of TPR in 4 weeks.

However, the pattern may not be as straightforward as it appears, as there are many factors involved, such as the lab capacity and the change of testing strategy during the period. This change has also occurred during the height of the expected spread in the community where the Exit PCR (comprising most of the PCR tests done during the period) may still be positive and a reduction in the number of PCRs done.

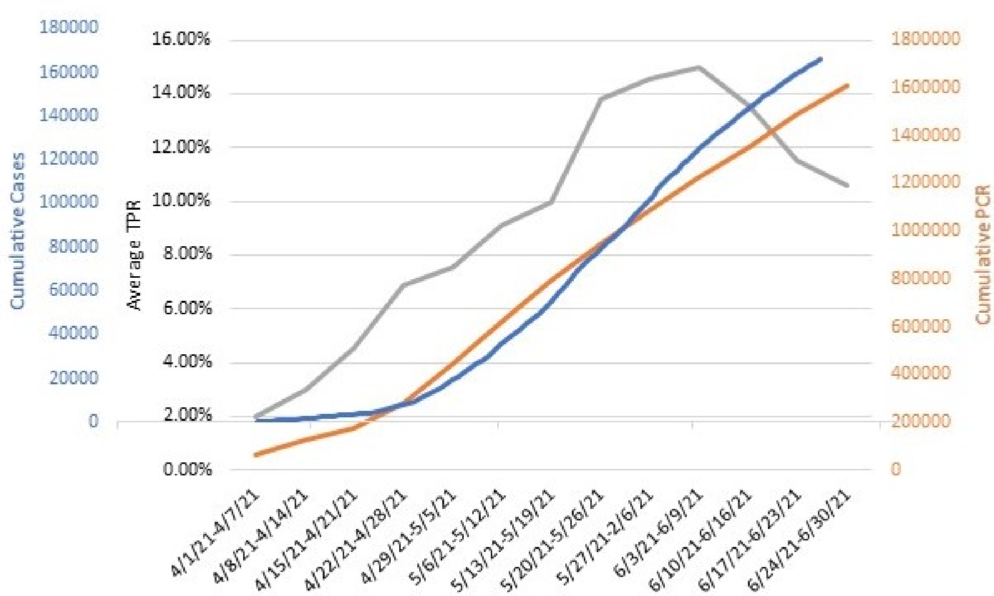


Figure 5: Relationship of Cumulative number of cases, the cumulative number of PCR and Observed TPR

The second step of 3-step analysis shows the relationship between the Observed TPR (7-day moving average), Cumulative tests done and the Cumulative cases during the period (Figure 5).

As per Figure 5, the increase of cases has occurred due to increased testing in the country starting from late April. The Observed TPR has also increased accordingly.

A community's mobility during COVID 19 pandemic is influenced by the measures taken by the authority's such as travel restrictions. Such decisions are made based on factors such as increasing caseload, fatality rate, and the capacity of their healthcare system. This google mobility report has its limitations since it was prepared using location data of active mobile phones. However, it is a good proxy measure of community mobility (Google, 2021).

Figure 6 depicts the changes in mobility during the period of the study and the corresponding changes of the epidemic curve. Two peaks of the mobility during the travel restricted period are representing relaxation of the lockdown to collect essentials.

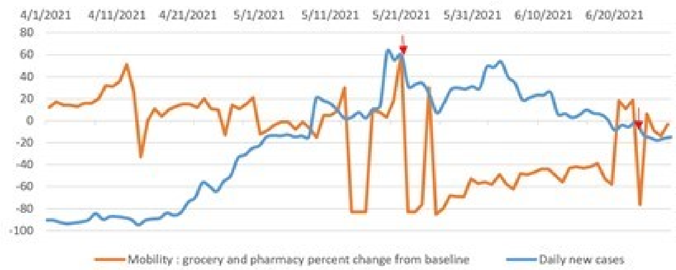
Change of mobility at retail and recreational spots, grocery and pharmacy, and use of public transport shows an inverse proportion with the incidence of COVID 19 cases. However, the effect of imposing 'lock down' in the form of strict travel restrictions as in Sri Lanka lags by about 3 to 4 weeks as shown in the graphs given above.

The peaks in mobility seen during the period of travel restrictions are due to relaxations of restrictions to allow citizens to purchase essential items. These do not carry a direct relationship with the caseload.

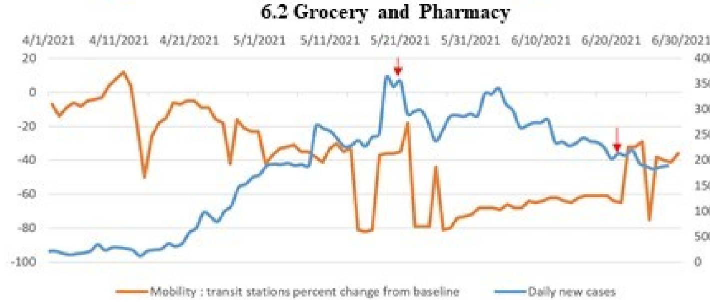
Strict travel restrictions have been imposed at the peak of daily case incidence. The case incidence has remained high, despite the increased residential stay for about 10 to 14 days, showing the lag that takes to show the effects of travel restriction.

Figure 7 shows the relationship of mobility change to the weekly average observed TPR and the weekly average PCR tests. It shows that the Observed TPR decrease lags the interventions of travel restrictions by an average of 3 to 4 weeks. As in the case of Sri Lanka, these graphs show that the effects of travel restrictions are seen as both a reduction of case numbers and as a reduction of observed test positivity rate, by which time the travel restrictions have been lifted in the country.

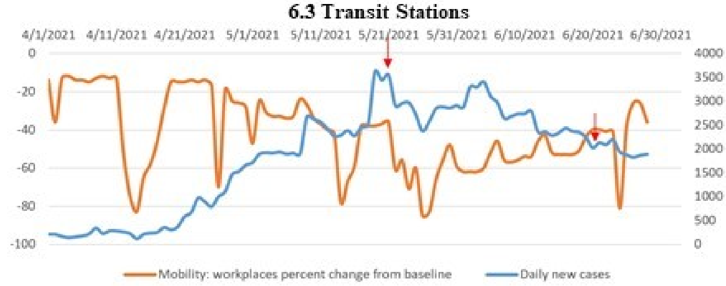
6.1 Retail and Recreational Spots



6.2 Grocery and Pharmacy



6.3 Transit Stations



6.4 Workplaces

6.5 Residential Areas

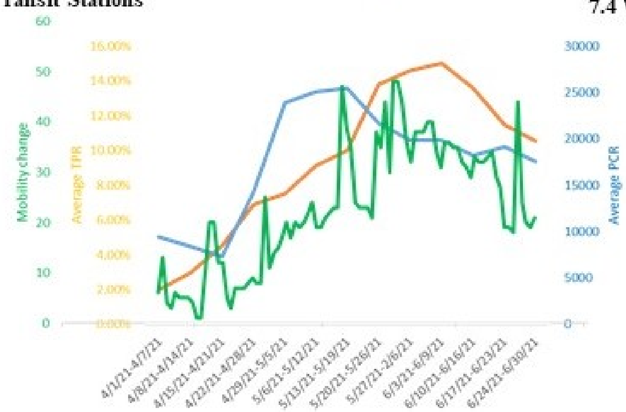
Figure 6: Relationship of the Change of Mobility by Area with Daily New Cases

7.1 Retail and Recreational Spots

7.2 Grocery and Pharmacy

7.3 Transit Stations

7.4 Workplace



7.5 Residential Areas

Figure 7: Relationship of the Change of Mobility by Area with the Average Observed TPR and Average PCR

The mobility data can be used to both predict the behaviour of the disease in the community and to evaluate the use of any form of 'lock down' in a community. However, as a single indicator, it cannot be used due to the limitations in delays related to the preparation of mobility data by global service providers and limitations of mobile and other smart devices use in a community. Due to these limitations, mobility data cannot be used to compare and predict the behaviour of the disease between 2 communities as a sole indicator. However, it can be used as a proxy indicator in combination with other proxy indicators.

The use of newer proxy indicators such as mobility data is emerging with the advancement of technology during the current COVID 19 pandemic. These proxy indicators are neither traditionally used in evaluating disease behaviour nor are invented to be used for the said purpose. These may include internet searches for influenza-like symptoms, social media usage related to COVID 19, and thermal readings from smart devices.

Discussion

Based on the COVID-related proxy indicators considered in this study, it is seen that the 'trend' of cases as depicted by weekly Observed TPR carries better information for decision making and evaluation of the methods to contain COVID 19 than using traditional proxy indicators such as the daily case numbers.

The reported numbers in cases can be less than the actual numbers due to non-detection of cases in the community, under-reporting, delays in reporting, and PCR backlog.

Trends of mobility changes and the trends of observed TPR together can be used to monitor and evaluate the effectiveness of the use of lockdown measures to contain the disease. Further, this also shows that such measures will only be effective as continuous lengthy travel restrictions; at least of one-month duration. The use of short-term forms of lockdown will not yield effective containment of the disease in the current context.

Adopting the use of such proxy indicators may help both in measuring the disease severity and the evaluation of the use of travel restrictions to contain the disease cost-effectively in a resource-limited setting.

The main limitations in the use of these proxy indicators include the time lag in receiving Google mobility data for real-time analysis and the relationship between the numerator and denominator of the observed TPR not being real-time. Therefore weekly trends to eliminate this error are better as opposed to daily values. The delaying of google mobility reports is of an average of about 2 days, as opposed to the trends in disease burden depicted in the form of observed TPR that lags by about 3 to 4 weeks. Hence, the delay in the publication of these reports is negligible in interpreting the effectiveness of lockdown measures. The use of Google mobility reports is also limited by the use of smart devices and internet facilities in a community. However, Sri Lanka has an internet penetration of 50.8% as of January 2021 with mobile connections amounting to 141.7% of the total population. Despite this, internet use is mostly concentrated in the urban parts of the country creating a disparity in internet and mobile use in different districts in the country. Google Community Mobility Reports are not generated on a regional basis for Sri Lanka, though this data is available for some countries. It is recommended to make regional Google Mobility Reports available for Sri Lanka to enhance the use of mobility data as a proxy indicator for disease behavior in COVID 19.

However, most major movements occur in cities when people travel for work and major disease spread tend to occur with such movements. Therefore, use of data from existing Google mobility reports for Sri Lanka is justifiable to an extent (Wijesekara et al., 2021).

The weekly moving average of observed TPR can be suggested to be used as a proxy indicator to measure the disease severity in the community while the relationship between the observed TPR and the trends of mobility changes may be used to form a reliable prediction model for the disease behaviour of the disease in a community that has significant use of smart devices. The weekly moving average TPR may cause bias, if the counts come from quarantined populations and not from random testing.

Multiple proxy indicators, when used in conjunction, can be used to interpret the pattern of Epi curve in COVID 19.

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