

Original Research



How much did Sri Lankans move during COVID-19 crisis?

Community mobility and public health interventions in retrospect

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Abstract

Introduction: During COVID-19 crisis, restricting the mobility of individuals was done through school, pre-school and university closure, work from home and imposing of curfew in Sri Lanka. Mobility of people is a proxy of social distancing interventions.

Objectives: To assess the mobility of Sri Lankans during COVID-19 crisis against the public health interventions implemented

Methods: We obtained the Google Community Mobility Report (GCMR) data for Sri Lanka for six location categories, namely grocery and pharmacy, parks, transit stations, retail and recreation, residential and workplaces, and calculated a new category named 'Out of Home Locations' (OHL). Percentage deviation from the baseline (PDB) was calculated by considering the median value for a reference period of "same day of the week" as zero. Key public health interventions influencing mobility and COVID-19 cases by date were listed. Minimum and maximum PDB were calculated for the categories of locations. Trend lines with and cases were plotted against public health interventions Cross correlation function was used to assess any lagged relationship between the trends in GCMR and COVID-19 cases.

Results: All categories of locations except residential areas showed negative PDBs. The maximum negative PDB for grocery and pharmacy, retail and recreation, transit stations, workplaces and parks and recreation categories were 92, 88, 81, 79, and 59, respectively. In contrast, the residential area category showed the highest positive PDB of 47. There was a close relationship between the school, pre-school and university closure, work from home and imposing and lifting of curfew and the PDB trends. Even after the total release of curfew, the PDB at OHL and residential categories remain at - 20 and 10, respectively. Cross correlation function between GCMR and COVID-19 cases was not statistically significant at any lag.

Conclusions & Recommendations: Sri Lankans have considerably reduced OHL mobility during the COVID-19 crisis, in connection with the implemented public health intervention. GCMR is a versatile tool in monitoring community mobility in Sri Lanka. It is recommended to share district-wise GCMR for Sri Lanka for better planning and monitoring of public health interventions.

Keywords: *google community mobility report, COVID-19, curfew, lockdown*

Introduction

COVID-19 Pandemic has demanded drastic public health interventions affecting all aspects of community life, including the limitation of mobility of people, though at times being criticized as not being backed by sound evidence, “asphyxiating the mobility of people, goods, and capital for very long”, and being interpreted as violation of civil liberties (1-6). Reducing the mobility of communities have been suggested to reduce COVID-19 transmission (7). For example, a study conducted among US states revealed that mobility patterns strongly correlated with COVID-19 case growth for most affected counties (n=20; r=0.7). This study also showed that when mobility dropped by 35-63% from the normal, COVID-19 transmission is unlikely to be seen for 9-12 days, and possibly even up to 3 weeks (8). In order to prevent the spread of the virus from person to person, people have been advised to stay at home as much as possible reducing the risk of exposure which could occur during commuting, shopping, schooling and working (2). Different non-pharmaceutical public health interventions such as stay-at home orders, curfews and lockdowns have been used to reduce mobility by different countries (9). Mobility data are important proxy measures of social distancing (7). Nevertheless, monitoring the compliance of the public to the recommended measures was a challenge.

One innovative solution that has been developed by Google, an international technology company has been the Google Community Mobility Report (GCMR), which is based on data via their location identifying services, such as Google maps (10). Even though Google has access to the location data of individuals, they are not usually shared due to privacy concerns. However, considering the benefits that the public health authorities may have of such location data, GCMR carries only aggregated data which cannot be used to identify individuals (11). The GCMR demonstrates the trends of movement in different geographic locations, categorized by different location types. Mobility patterns are shown in two different ways, namely the headline numbers and the trend graph. The headline number compares the percentage deviation from the baseline, which

could either be positive or negative. The trend graph illustrates the percentage change in mobility in the six weeks before the date of reporting (11).

The baseline for mobility is calculated by considering the median value for the period from 03-01-2020 to 06-02-2020 on the “same day of the week” as zero. Percentage of deviation from baseline (PDB) is calculated as follows:

$$PDB = \frac{\text{Baseline mobility} - \text{Observed Mobility}}{\text{Baseline Mobility}} \times 100$$

As per the equation, PDB is the amount of change of mobility from the “normal”, which can either be positive or negative. A positive PDB means that more mobility has been observed at a location compared to the baseline, whereas a negative PDB means that less mobility has been observed at a location compared to the baseline. For example, a PDB of 20 means an increase of mobility by 20% compared to the baseline, while -20 indicates a decrease of mobility by 20%.

The PDB is plotted every day for six types of locations, namely grocery and pharmacy, parks, transit stations, retail and recreation, residential and workplaces. The country- and region-wise, community mobility reports are published by Google until they would be deemed necessary by public health officials for the control of COVID-19 outbreak.

Many public health authorities and researchers globally have used GCMR as a proxy of social distancing in assessing the effectiveness of public health interventions. In USA, community mobility in the metropolitan areas of Seattle, San Francisco, New York City and New Orleans has declined with community mitigation policies implemented, and with rising caseloads (12). A study from India showed that one day after lockdown, the community mobility has dropped in retail and recreation, parks, transit stations, and workplaces by 70.51%, 64.26%, 46.17%, 65.6% and 60.03%, respectively. However, the residential place mobility has increased by 26.32% (13). In addition, some researchers have used community mobility as an important model input in predicting the spread of COVID-19 (14-16).

The interventions adopted by countries in managing COVID-19 are broadly classified as suppression which involves immediate lockdown of cities at the epicenter or as mitigation that slows down the outbreak but not stopping the outbreak so that the health care system could cope up with the demand. Sri Lanka too has implemented a series of public health interventions, a mixture of suppression and mitigation strategies to prevent the spread (17). Some interventions were aimed at prevention of exposure by staying at home as much as possible and restricting mobility to high risk locations (16-18). In addition, restricting mobility was essential among vulnerable groups such as elderly who reported adverse health outcomes (19). School, preschool and university closure and work from home provisions were implemented. Curfew was imposed initially in high risk areas for a few hours per day with subsequent expansion into the whole island extending for several days (20-21). In addition to interventions limiting the community mobility, a whole range of other interventions such as active case detection, contact tracing, home and institutional quarantine, admitting infected individuals, and community-wide promotion of hand hygiene, cough etiquette and maintaining 1m distance when out of home were also implemented (18). All these interventions are essential for the prevention and control of COVID-19.

The national level public health authorities in Sri Lanka have attempted to monitor the adherence to prescribed interventions through an organized system of active inquiry from the district level health staff (20). However, an objective measurement of community mobility over time was essential to see the effectiveness of the above-mentioned interventions. The objective of this research was to assess community mobility of Sri Lankans during COVID-19 crisis against the public health interventions implemented.

Methods

We downloaded the GCMR as from 15 February 2020 to 15 July 2020, which included data for 135 countries or regions of countries (10). We selected the

records for Sri Lanka. It should be noted that subnational breakdowns of GCMR was not available for districts or provinces for Sri Lanka. GCMR had PDB for six location categories, namely grocery and pharmacy, parks, transit stations, retail and recreation, residential and workplaces. It was essential to have a single PDB representative of all five out of home location categories, which would be easier for comparison than five different PDBs. Hence, we calculated a PDB for Out of Home Locations (OHL) by taking the average of five location categories except residential areas. Thus, in addition to the six PDB provided by default in the GCMR data, we had an additional PDB for OHL, with a total of seven location categories for PDB analysis.

We identified public health interventions with dates which could affect community mobility by reviewing the Situation Update of the Director General of Health Services on COVID-19 (17). The dates of these interventions were cross-checked with the daily media statements issued by the Department of Government Information, President's Media Division, online news items, previously published literature and a diary maintained by the research team by observing local news bulletins (16,17, 21-24). We selected the public health interventions which were directly related to the control of community mobility. Since the GCMR was providing a mobility value for the whole country, after reviewing the detailed timeline of interventions, considering the possible impact of such interventions island wide, we prioritized 21 interventions for the analysis.

We obtained the daily COVID-19 case number from daily situation reports of the Epidemiological Unit (25). Even though the daily number of COVID-19 cases was clearly a mixed group, consisting different categories of patients such as foreign returnees, persons from different geographic locations and diverse sources of infection, we resorted to that as a measure of disease trend in the country.

An Excel sheet with daily PDB for the seven location categories, public health interventions and cases was prepared. The analysis was done using the Statistical Package for Social Science (SPSS) version 21.

Minimum and maximum PDB were calculated for all location categories. Trend lines with PDB for the seven location categories and COVID-19 cases were plotted against public health interventions. We visually inspected for the association between PDB for seven location categories, COVID-19 cases and public health interventions. In addition, we used cross-correlation to see if there was correlation between the time series of PDB for OHL and cases. Cross-correlations help researchers understand if two variables are related to each other and if so, whether movement in one variable tends to precede or follow movement in the other (26). The values of two time series variables may move together at the same point in time, or it could be that movement in one variable precedes or follows movement in another variable. We analyzed the lagged effect of the mobility restriction by using cross-correlation function in the SPSS.

Results

The distribution of the GCMR for the study period is presented in Table 1. The largest negative PDB (-92) was observed for grocery and pharmacy on 22 March 2020. When considering the out of home location categories, the smallest negative PDB (-59) was reported for parks, which was reported on 22 March 2020. It should be noted that the maximum negative PDB for workplaces was reached on 13 April 2020. The PDB for OHL was -77.6, as per 21 March 2020. The maximum positive PDB for residential areas (47%) was observed on 3 April 2020.

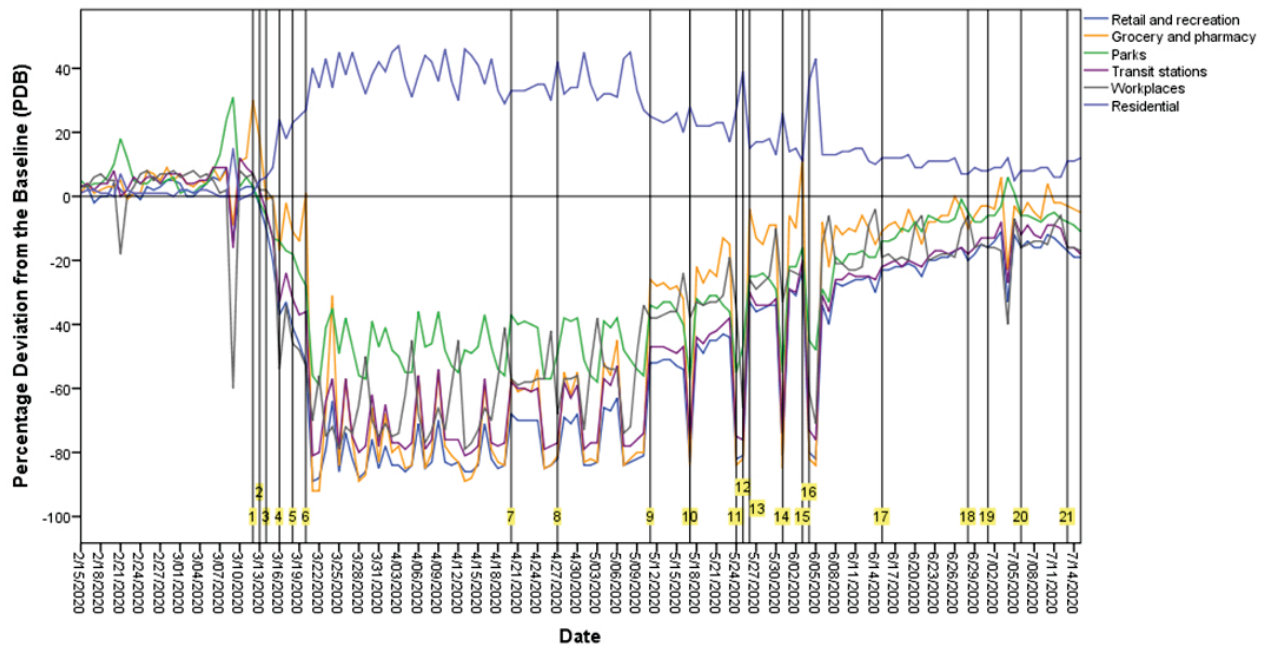
The distribution of PDB for different location categories over time is shown in Figure 1. It is evident that over the series of public health interventions implemented during the study period, a drastic drop in PDB was observed in all location categories except

in the residential areas, which saw a simultaneous positive PDB. From there onwards, except for parks, all other out of home location categories were able to maintain a negative PDB of over 50.

With step-wise lifting-off of the island wide curfew, commencing from 20 April 2020 showed a gradual reduction of the negative PDB. Parallely, gradual decline of the positive PDB for residential areas was also noted. Even after the total release of curfew, the PDB at OHL continued to be around -20, while the same at residential areas remained to be 10.

Figure 2 shows the distribution of change of community mobility in the residential areas, OHL and COVID-19 cases reported by the Epidemiology Unit on a daily basis, irrespective of whether they arrived from a foreign country or not or their geographic distribution within the country. It was evident that almost all of the spikes in daily COVID-19 case trend except the last one, occurred at times where PDB values at OHLs are lower and at residential areas are much higher. However, the last spike, which was the largest has occurred at a time where PDB values at OHLs and residential areas are much closer to the baseline.

Figure 3 shows the cross-correlation functions for PDB for residential areas and OHL at lag 1 to five. The strongest negative cross correlation function was observed at lag 0 which was -0.972. Figure 4 shows the cross correlation coefficients for residential areas and cases at lag 1 to 5. Negative, yet non-significant cross correlation coefficients were observed for all lags for PDB for residential areas and OHL. Figure 5 shows the cross correlation coefficients for OHL and cases at lag 1 to 5. The positive yet non-significant cross correlation coefficients were observed for all lags between PDB for OHL and cases.



Notes:

No	Date	Action
1	12.03.2020	Closure of schools
2	13.03.2020	Closure of preschools and universities
3	14.03.2020	Ban of public events, Closure of cinema, zoo and public parks
4	16.03.2020	Closure of museums
5	18.03.2020	Curfew in selected areas in Puttlam and Gampaha Districts
6	20.03.2020	Island-wide curfew; Launch of Work from Home
7	20.04.2020	Commencement of curfew release intermittently except in Colombo, Gampaha, Kalutara and Puttalam districts
8	27.04.2020	Curfew lifted in all districts except Colombo, Gampaha, Kalutara and Puttalam; Night time curfew continues in all districts
9	11.05.2020	Curfew lifted in all districts except Colombo and Gampaha; Night time curfew continues in all districts
10	17.05.2020	Island Wide Curfew
11	24.05.2020	Island Wide Curfew
12	25.05.2020	Island Wide Curfew
13	26.05.2020	Curfew in the night in all districts
14	31.05.2020	Island wide Curfew
15	03.06.2020	Island wide Curfew
16	04.06.2020	Island wide Curfew
17	15.06.2020	National Parks Reopen
18	28.06.2020	Curfew totally lifted in the country
19	01.07.2020	Museums reopen
20	06.07.2020	Schools reopen
21	13.07.2020	Schools close again

Figure 1: Distribution of Percentage Deviation from Baseline (PDB) by Location Categories and Public Health Interventions

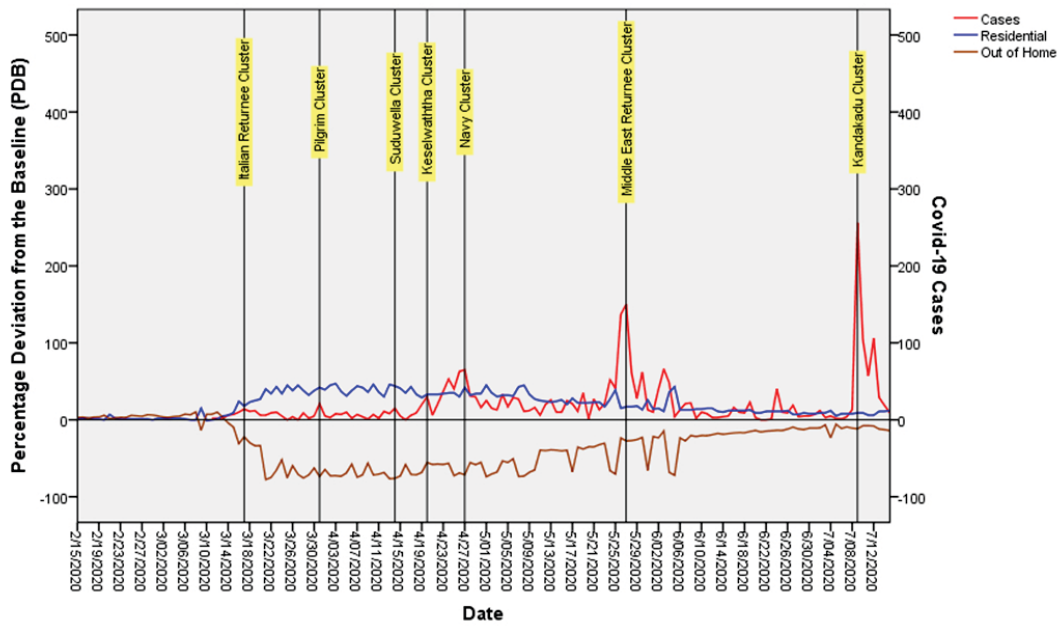


Figure 2: Daily Distribution of Percentage Deviation from Baseline (PDB) at Residential and Out of Home Locations, Covid-19 Cases and Peaks of Clusters

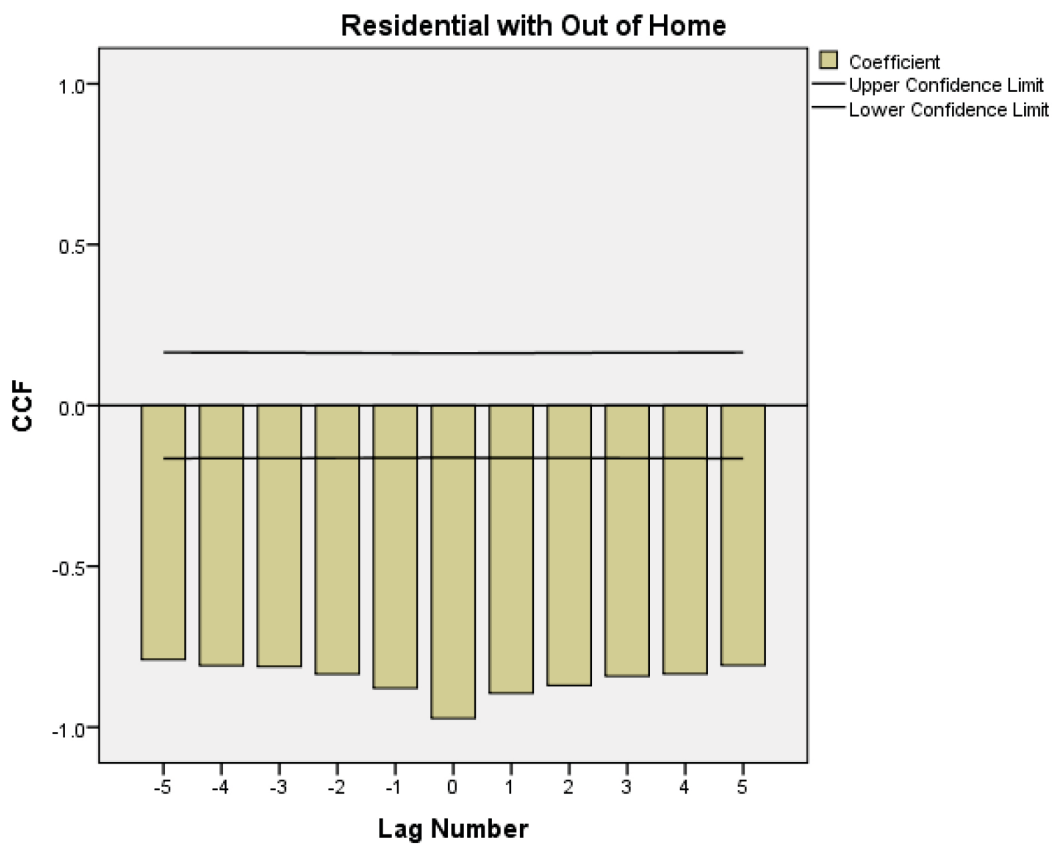


Figure 3: Cross Correlation Functions for PDB for Residential Areas and OHL

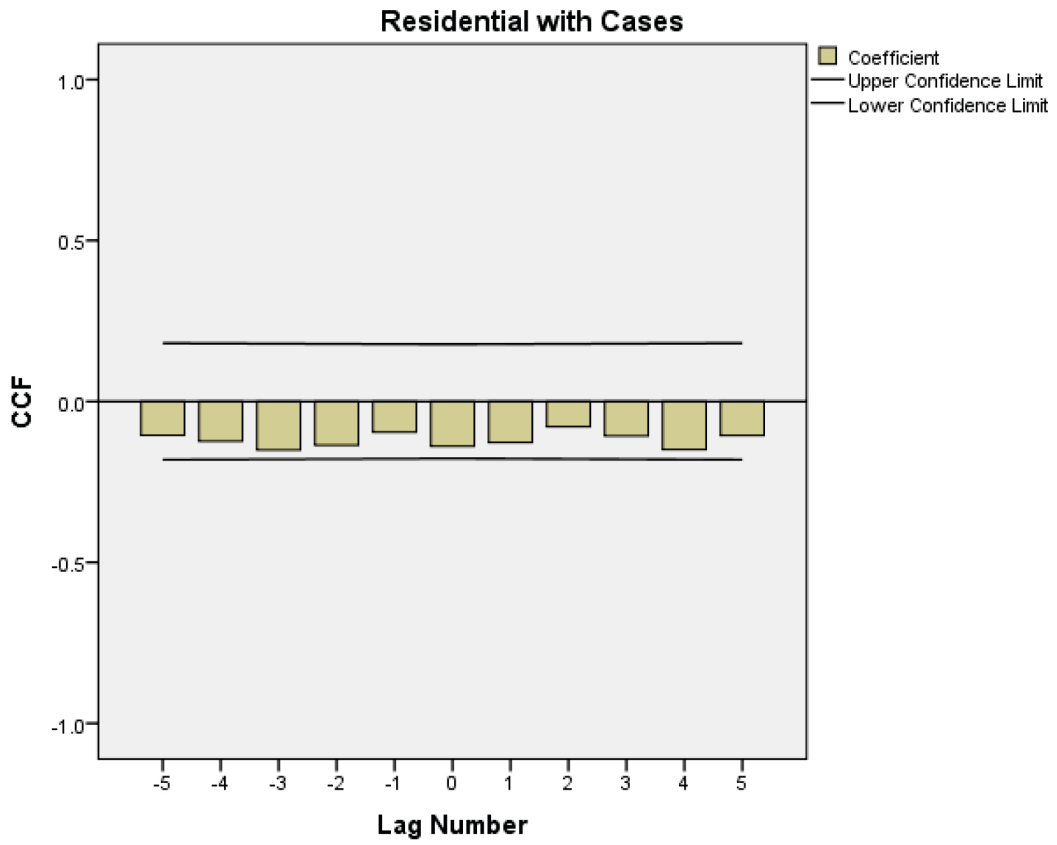


Figure 4: Cross Correlation Coefficients for Residential Areas and Cases

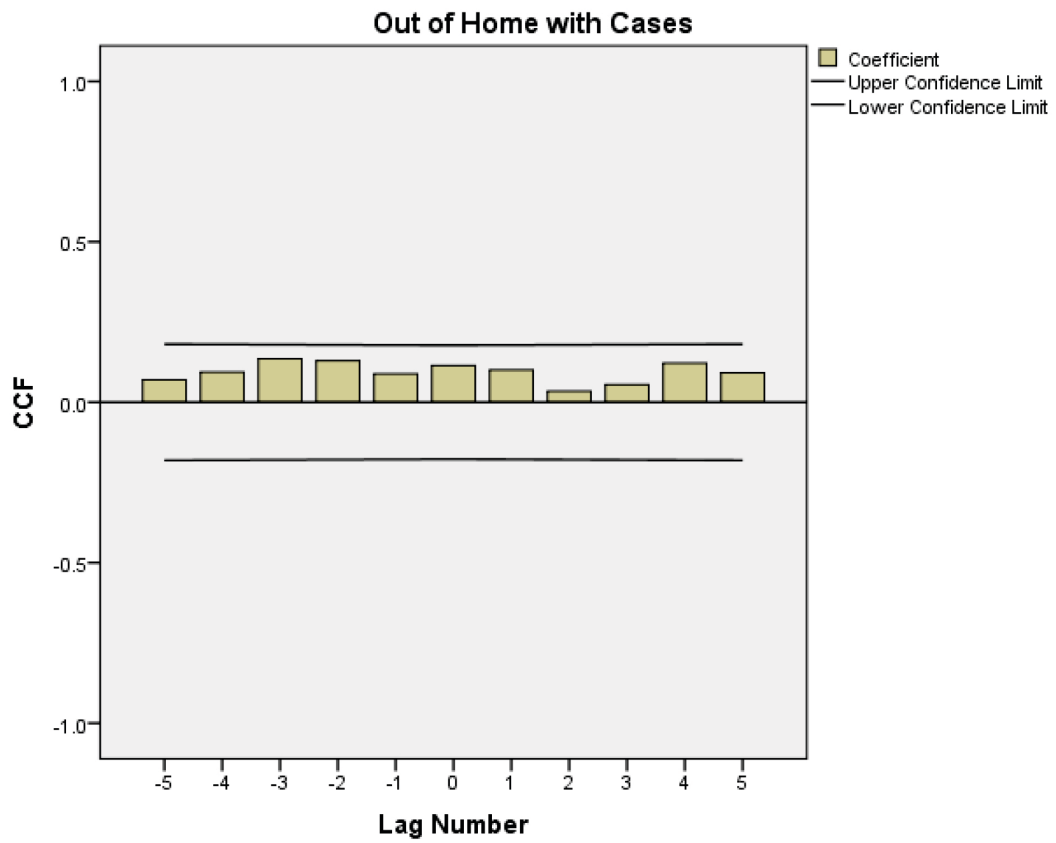


Figure 5: Cross Correlation Coefficients for OHL and Cases

Discussion

Freedom of mobility is a right that all humans enjoy, however, this freedom would not have ever been restricted to such magnitude in the recent past than during COVID-19 crisis (5-6). While a whole of society approach with the public health leadership is essential in the prevention and control of the COVID-19 pandemic, including case detection and management, case and contact tracing, and quarantine, both at home and at institutions, risk communication and awareness raising aimed at promoting healthy habits were critical, the emphasis on limiting community mobility as key public health intervention in countering the COVID-19 outbreak cannot be underestimated (27).

The need to objectively monitor the effectiveness of public health interventions aimed at restricting community mobility was a need of the day. GCMR could be used as a versatile tool in monitoring the effectiveness of public health interventions to curtail the outbreak (10). In addition to that, the level of community mobility, as measured as PDB could be used as a proxy indicator of a level of social distancing, which becomes a critical input for prediction models (14-16).

During this study, the trend of GCMR data, along with key interventions to reduce person to person spread of the disease, as well as the daily COVID-19 case numbers for Sri Lanka were observed. It should be noted that the GCMR was used by the Disaster Preparedness and Response Division, of the Ministry of Health throughout the outbreak to understand the adherence to the measures to minimize community mobility.

The PDB oscillations are unique to each location category, as the mobility is compared at a given location in relation to the baseline at the same location. Hence, inter-category comparison results must be interpreted carefully. It was evident that along with the different public health interventions, considerable negative PDB were observed, while the same in the residential areas showed drastic positive PDB. As observed from the current analysis, the maximum negative PDB for grocery and pharmacy,

retail and recreation, transit stations, workplaces and parks and recreation were 92, 88, 81, 79 and 59 respectively, while the residential areas showing the highest positive percentage rise of 47. A similar study in India showed that one day after lockdown, the community mobility has dropped in retail and recreation, parks, transit stations, and workplaces by 70.51%, 64.26%, 46.17%, 65.6% and 60.03% respectively. However, the residential place mobility increased only by 26.32% (13). Sri Lankan mobility results compared with those from India can be interpreted as evidence not only to the effectiveness of the implementation of the public health interventions in Sri Lanka, but also to the extent that Sri Lankans have sacrificed their freedom of mobility for their own and community good. However, such country-wide comparisons, as stated in the literature on GCMR, could also be questionable due to the country-wide discrepancies which may exist in the definition of location category (28).

It was found that the maximum negative PDB for workplaces was reached on 13.04.2020 which was almost three weeks after the other four OHL reached their maximum negative PDB, which was falling on the Sinhala/Hindu New year day. In addition, the lowest negative PDB was observed for parks. This may be explained by the fact that people continuing to use the parks even during the COVID-19 mobility restrictions.

The study found that the maximum positive PDB for residential areas was observed on 03.04.2020 with a 47. One immediate reason that would have contributed to this event would have been public fear following the third and fourth COVID-19 deaths in Sri Lanka which occurred on 1st and 2nd April 2020. In addition to the six location categories for which PDB was reported, the research team created an aggregated measure for OHL, by taking the average deviations of the PDB in five OHL. This summary PDB for OHL was useful as a single measure in comparisons against PDB in residential areas.

It was encouraging to see that even after the total release of curfew, the PDB at OHL remains to be around -20 while the same at residential areas continues to be around 10. This could at least partially

be due to the continued adherence to the prescribed guidance by Sri Lankans, and schools and universities not returning to pre-COVID-19 baselines. Further, it was noted that the island wide weekend curfews imposed even after lifting off the full curfew has been almost effective in minimizing the mobility, as much as to the same extent during continuous island wide curfew. For example, as evident from Figure 1, the PDB was stable around 40 in residential areas during the sustained island wide curfew. Even though the PDB gradually decreased with the lifting off the island wide curfew to fluctuate around 20, with weekend curfew days, the PDB shot to 30, even peaking up to 40.

Easing of social distancing needs to be considered very carefully, since small increases in contact are likely to risk resurgence of the apparently under control COVID-19 conditions (7). Nevertheless, it was alarming to see that the largest spike in the daily COVID-19 case trend has occurred at a time where the PDB has been minimal since the onset of the outbreak, which signals the high risk that the country ran in rapid spread of any possible spillover of cases. This spike indicates the large number of COVID-19 cases reported among the persons and their contacts in an around the Kandakadu Rehabilitation Center, Quarantine Center and the neighboring military base (25, 29). The strong contact tracing mechanism still in full action as well as drastic quarantine measures, both at home and at quarantine centers would have contributed to the control of massive Kandakadu spike. However, the massive public health risk the country would have entered in the absence of above quarantine measures at a stage where community mobility would have been almost close to the baseline cannot be over-emphasized. It was also noted that the schools were closed again after being reopened after over three months of closure as a response to the Kandakadu cluster (22). The suppression of the Kandakadu spike marks the massive outbreak risk that Sri Lanka has averted through timely public health measures, without which it would have led to an uncontrolled spread of COVID-19 to many parts of the island.

Even though GCMR is a powerful tool, it has its own deficiencies and biases as well.

Firstly, GCMR is based on location data which are collected through mobile phones and devices which have enabled their location (10). This means that Google can only access limited location data of users who 'opt in' or agree to be tracked within limits, in return for having their experience improved by using that data, for instance through recommendations on good restaurants near current location, based on their dietary styles. Therefore, if a person has opted in to be tracked by location, that person will not be included in the Google community mobility report.

Secondly, for a person to be location tracked by Google, such a person should possess a smart phone which are considered to comprise around 30-40% of phones in Sri Lanka, running Android of a sufficiently recent version and having opted-in for location recording (30). This means that the GCMR would be reflecting a very small sub-set of people, who are heavily biased to urban elite. It is reported that for 21.3 million population in Sri Lanka, there are 31.8 million mobile phones, with 149% of the population having a mobile phone. There are 10.1 million internet users in Sri Lanka, which indicates that 47% of the population is having access to internet, while 6.7 million persons (30% of the population) are active social media users. It is reported that 98% of persons use social media via a mobile phone (31). We could not find how many of the mobile phone social media users had enabled location data. However, we can approximately estimate that the maximum sample of the GCMB to be around 6.7 million persons, if we assume all mobile phone social media users had enabled their location services.

At present, GCMR provides a single mobility data per day. Lack of mobility data by different times of the day limits interpretation detailed analysis of the data. In addition, regional disparities of the use of location-enabled mobile phones in Sri Lanka may be compounded by other socio-economic factors, such as urbanization, poverty, literacy and e-literacy. Thus, the need for GCMR data by districts of Sri Lanka could be very helpful. Even though sub-national reports have been generated for some countries, such data were not available for Sri Lanka. District-wise GCMR data if available would reflect inter-district variability of the mobility and useful for better

monitoring of public health interventions. It is recommended that district-wise GCMR to be generated and shared by Google, which could be used by public health professionals during the current as well as future outbreaks. As shown in Figure 3, strong negative cross correlation functions were observed between PDB at residential areas. It also shows that PDB at residential areas and OHL respond similarly and simultaneously to some exogenous factors. These exogenous factors could be the numerous public health interventions implemented, as shown in Figure 2. However, a negative cross correlation function value was observed between trends of PDB at residential areas and the cases, while a positive cross correlation function value was observed between the trends of PDB at OHL and COVID-19 cases. However, none of the above cross correlation function values were statistically significant at any lag. The lack of significant cross correlations between mobility and COVID-19 case trends must be interpreted carefully. Firstly, clusters of the COVID-19 outbreak occurred in specific identified geographical locations, and there was no community transmission during the period of concern of this paper. Secondly, almost all cases were identified and quarantined irrespective of the population-based mobility restrictions.

Conclusions & Recommendations

The GCMR during the study period demonstrated that Sri Lankans have adhered to the government public health recommendations including that for staying at home. GCMR could be a useful tool in planning and monitoring of public health interventions not only against the spread of COVID-19, but also against other infectious diseases. The usefulness of GCMR can be further enhanced if sub-national level data are made available. Hence, it is recommended that at least district-wise breakdowns of GCMR are made available for Sri Lanka.

Public Health Implications

Information on community mobility through tools such as the Google Community Mobility Reports could be used by public health practitioners for decision support during the management of infectious disease outbreaks such as COVID-19. Availability of such data at subnational level could be useful in planning, implementation and management of targeted interventions for outbreak management.

Author Declarations

Competing interests: No competing interests.

Ethics approval and consent to participate: The study was based on openly available data on the internet. Human subjects were not involved hence ethics approval was not obtained.

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Author contributions: NWANYW conceptualized the research project, analyzed the data and wrote the report. UBW and JSW downloaded and analyzed GCMR data.

References

1. WHO. *Overview of Public health and social measures in the context of COVID-19*. Available from: <https://www.who.int/publications/i/item/overview-of-public-health-and-social-measures-in-the-context-of-covid-19>. Accessed 18 May 2020.

2. WHO. 2020. *Public health criteria to adjust public health and social measures in the context of COVID-19*. Available from: <https://www.who.int/publications-detail-redirect/public-health-criteria-to-adjust-public-health-and-social-measures-in-the-context-of-covid-19>. Accessed 12 May 2020.
3. WHO. 2019. *Non-pharmacological public health measures for mitigating the risk and impact of epidemic and pandemic influenza Annex: Report of systematic literature reviews*. Available from: <https://apps.who.int/iris/bitstream/handle/10665/329439/WHO-WHE-IHM-GIP-2019.1-eng.pdf>. Accessed 25 July 2020.
4. Roth S. *Weak evidence for strong pandemic interventions: a 2019 WHO warning for the current COVID-19 crisis*. Kybernetes. 2020 (ahead-of-print). doi: 10.1108/K-04-2020-0248.
5. Milano B. *Restricting civil liberties amid the COVID-19 pandemic*. Harvard Law Today, 21 March 2020. Available from: <https://today.law.harvard.edu/restricting-civil-liberties-amid-the-covid-19-pandemic/>.
6. Farr C. *The COVID-19 response must balance civil liberties and public health - experts explain how*. CNBC, 18 April 2020. Available from: <https://www.cnbc.com/2020/04/18/covid-19-response-vs-civil-liberties-striking-the-right-balance.html>.
7. Nouvelle P, Bhatia S, Cori A, Ainslie KEC, Baguelin M, Bhatt, S, et al. Report 26 - Reduction in mobility and COVID-19 transmission. *Nat Commun* 2020; 12(1): 1090. doi: 10.1038/s41467-021-21358-2
8. Badr HS, Du H, Marshall M, Dong E, Squire MM, Gardner LM. Association between mobility patterns and COVID-19 transmission in the USA: a mathematical modelling study. *Lancet Infect Dis* 2020; 20(11): 1247-1254. doi: 10.1016/S1473-3099(20)30553-3.
9. Daniel D, Dale B, Stylianou N, Lowther E, Ahmed M, Arenas I de la T. *Coronavirus: the world in lockdown in maps and charts*. BBC News, 7 April 2020. Available from: <https://www.bbc.com/news/world-52103747>.
10. Google LLC. *COVID-19 Community Mobility Report*. Available from: <https://www.google.com/covid19/mobility?hl=en>. Accessed 16 July 2020.
11. Google LLC. *Overview - Community Mobility Reports Help*. Available from: https://support.google.com/covid19-mobility/answer/9824897?hl=en&ref_topic=9822927. Accessed 13 July 2020.
12. Lasry A, Kidder D, Hast M, Poovey J, Sunshine G, Winglee K, et al. Timing of Community Mitigation and Changes in Reported COVID-19 and Community Mobility - Four U.S. Metropolitan Areas, February 26–April 1, 2020. *Morb Mortal Wkly Rep* 2020; 69(15): 451-457. doi: 10.15585/mmwr.mm6915e2.
13. Saha J, Barman B, Chouhan P. Lockdown for COVID-19 and its impact on community mobility in India: An analysis of the COVID-19 Community Mobility Reports, 2020. *Child. Youth Serv Rev* 2020; 116: 105160. doi: 10.1016/j.childyouth.2020.105160.
14. Wang H, Yamamoto N. Using Partial Differential Equation with Google Mobility Data to Model COVID-19 in Arizona. *Math Biosci Eng*. 2020; 17(5): 4891-4904. doi: 10.3934/mbe.2020266.
15. Picchiotti N, Salvioli M, Zanardini E, Missale F. COVID-19 pandemic: a mobility-dependent SEIR model with undetected cases in Italy, Europe and US. *Epidemiologia e Prevenzione* 2020; 44 (5-6) Suppl2: 136-142. doi: 10.19191/EP20.5-6.S2.112.
16. Hewage S, Wickramasinghe N, Jayakody S, Samaranyake D, Prathapan S, Arambepola C. Social distancing and its impact on flattening the COVID-19 curve in Sri Lanka. *J Coll Community Physicians Sri Lanka* 2020; 26(1): 65-70. doi:10.4038/jccpsl.v26i1.8314.
17. Director General of Health Services. COVID-19 Situation Update -30.06.2020. PowerPoint Presentation presented at: Ministry of Health Operational Meeting. June 30 2020. Colombo, Sri Lanka.
18. The College of Community Physicians of Sri Lanka. Flattening the epidemic curve of COVID-19 in Sri Lanka: the public health response. *J Coll Community Physicians Sri Lanka* 2020; 26(1): 56-64. doi: 10.4038/jccpsl.v26i1.8311.
19. Mallapaty S. The coronavirus is most deadly if you are older and male - new data reveal the risks. *Nature* 2020; 585(7823): 16-17.

20. Disaster Preparedness and Response Division. Social distancing monitoring tool through Regional Directors of Health Services of Sri Lanka. Colombo, Sri Lanka. Accessed 30 July 2020.
21. Department of Government Information. COVID-19 Official Document. Department of Government Information. Available from: <https://www.dgi.gov.lk/news/press-releases-sri-lanka/covid-19-documents?start=60>. Accessed 24 July 2020.
22. Colombopage. Sri Lanka closes schools again for a week as risk of COVID-19 spreading rises. Colombopage, Available from: http://www.colombopage.com/archive_20B/Jul12_1594564802CH.php. Accessed 12 July 2020.
23. Lanka Education. Sri Lanka to Reopen all Schools July 29 & August 10 under two stages · Lanka Education News, 1 November 2020. Available from: <https://www.lankaeducation.com/sri-lanka-to-reopen-schools-from-june-29/>.
24. President's Media Division. Local News Archives. President's Media Division. Available from: <http://www.pmdnews.lk/category/local-news/>. Accessed 25 July 2020.
25. Epidemiological Unit. COVID-19 Daily Situation Report. Colombo, Sri Lanka. Available from: http://www.epid.gov.lk/web/index.php?option=com_content&view=article&id=225&lang=en. Accessed 15 November 2020.
26. Methods.sagepub.com. Learn About Time Series Cross-Correlations in SPSS With Data From the USDA Feed Grains Database. Available from: <https://methods.sagepub.com/dataset/howtoguide/time-series-cross-correlations-in-us-feedgrains-1876-2015>. Accessed 6 October 2020.
27. OECD. COVID-19: Protecting people and societies. OECD, 31 March 2020. Available from: <http://oecd.org/coronavirus/policy-responses/covid-19-protecting-people-and-societies-e5c9de1a/>.
28. Open CPM. *Comparing Google Community Mobility Reports Across Countries*. Available from: https://www.openriskmanagement.com/comparing_google_community_mobility_reports_across_countries/. Accessed 19 May 2020.
29. Hettiarachchi, Deane R, Rathnayake M. *Ease up with care*. The Sunday Times, 14 June 2020. Available from: <http://www.sundaytimes.lk/200614/news/ease-up-with-care-405851.html>.
30. Ratwatte JC. (Dialog Axiata PLC). Email to: Wijesekara, NWANY (Disaster Preparedness and Response Division, Ministry of Health, Sri Lanka). Accessed 28 July 2020.
31. Hootsuite & We Are Social. *Digital 2020: Sri Lanka. Data Reportal – Global Digital Insights*. Available from: <https://datareportal.com/reports/digital-2020-sri-lanka>. Accessed 18 February 2020.