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Lockdown for COVID-19 and its impact on community mobility in India: An analysis of the COVID-19 Community Mobility Reports, 2020

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ARTICLE INFO
Keywords:
COVID-19
Lockdown
Spatial-temporal analysis
Google community mobility reports
Community Mobility
India

ABSTRACT

Background: Coronavirus disease (COVID-19) is a novel public health problem threatening the whole world. As an upshot, countrywide lockdown due to COVID-19 pandemic has been supportive of changing community mobility trends of various place categories including retail and recreation, groceries and pharmacies, parks, transit stations, workplaces, and residential in India.

Objective: To analyze the impact of lockdown for COVID-19 on community mobility using spatial time-series change over different states and union territories (UTs) of India.

Data & Methods: This study has been organized based on states & UTs wise time-series data of the daily percentage of change of community mobility from baseline in India, collected from 15th February to 30th April 2020. Conditional formatting techniques, time-series trends plotting method, spatial inverse distance weighted (IDW) interpolation mapping techniques have been employed to show pre and post lockdown mobility trends due to COVID-19 i.e. to fulfill the objective.

Results: Across India, retail and recreation, grocery and pharmacy, visits to parks, transit stations, and workplaces mobility dropped by −73.4%, −51.2%, −46.3%, −66% and −56.7% respectively. Visits to residential places mobility increased by 23.8% as people mostly stayed home during the lockdown. The COVID-19 lockdown started on 24 March 2020 and just gone one day (March 25, 2020) of the beginning of lockdown, there have a decreased in percentage (−70.51% in retail and recreation mobility), (−64.26% in grocery and pharmacy mobility), (−46.17% in parks mobility), (−65.6% in transit stations mobility), (−60.03% in workplaces mobility) from baseline in compared to the pre-lockdown period and residential mobility has been increased in percentage (26.32%) from baseline due to people stayed home during the lockdown for COVID-19 pandemic in India.

Conclusion: Study figures out mobility trends over time during pre-lockdown and after lockdown period across different categories of places such as retail and recreation, groceries and pharmacies, parks, transit stations, workplaces, and residential, which can be used in public health strategies to drop the spread of COVID-19.

1. Introduction

Globally, Coronavirus disease (COVID-19) is a novel public health problem threatening the whole world amid sudden appearance and spread of novel Coronavirus (2019-nCoV) or the severe acute respiratory syndrome Coronavirus 2 (SARS-CoV-2) (Jin et al., 2020; Lai, Shih, Ko, Tang, & Hsueh, 2020; Peeri et al., 2020; Singhal, 2020; Wang, Horby, Hayden, & Gao, 2020; WHO, 2020a). On March 11, 2020, World Health Organization (WHO) has declared the novel COVID-19 outbreak as a global pandemic (WHO, 2020a). COVID-19 is a vastly contagious disease rapidly spreading from its origin in Wuhan City, Hubei Province of China to the rest of the world in December 2019. Globally, till 7th June 2020 as of 3:47 pm CEST, 6,799,713 confirmed cases of Coronavirus disease, including 397,388 deaths have been reported and 216 countries, territories have been affected by COVID-19 pandemic (WHO, 2020b). In India, as of 7th June 2020 as of 08:00 IST (GMT + 5:30), Ministry of Health and Family Welfare, the Government of India reported, a total of 246,628 confirmed cases and 6929 deaths have been reported speeded over 35 states and UTs (MoHFW, 2020).

According to WHO, globally, up to March 23, 14,509 people have died with 1727 new death cases and a total of 332,930 confirmed cases have been contaminated by COVID-19 with 40,788 new confirmed cases (WHO, 2000b). In India, just before the lockdown, the number of confirmed cases of COVID-19 reaches to 499 (MoHFW, 2020; India India Today, 2020). For that very situation, at midnight on 24th March of 2020, the Government of India has declared a countrywide COVID-
19 lockdown for three weeks (Ministry of Home Affairs, 2020; Pulla, 2020). On 14th April, the Government of India extended the countrywide lockdown until 3 May, again on 1st May; lockdown was extended further by two weeks until 17th May; and on 17th May, the lockdown was further extended till 31 May by the National Disaster Management Authority (Lancet, 2020; Sharma, Prabhu, & Ghosh, 2020; Livemint., 2020; Tribune News India, 2020). On 30 May, it was announced that the continuing lockdown would be additionally extended up to 30 June in containment areas, with services resuming in a phased manner starting from 8 June 2020 which is termed as “Unlock 1” (Sharma and Ghosh, 2020). But this countrywide lockdown more or less all retail and recreational activities, groceries and pharmacies activities (permissible with maintaining social distancing), tourism activities, transit station activities, workplaces activities have been ordered to stop. Therefore, the lockdown has been important for dropping community mobility of the entire 1.3 billion human beings of India as a precautionary measure fighting against the COVID-19 pandemic (Gettleman & Schultz, 2020; Lancet, 2020).

Mobility is a necessary part of human being life. People move for different reasons, like going to workplaces, retail and recreation, parks, educational institutions, etc. Asian cities offer various means of commuting: walking, cycling, motorcycles, public and mass transport, micro-mobility, para-transit, private cars, public taxis, and ride-hailing systems (United Nations, 2020). The outbreak of COVID-19 had a profound impact on mobility (Dela Cruz, 2020; Wellenius et al., 2020). Countries and cities in the region or state have declared lockdown to measures or to restrict pupil mobility and social gatherings. Across India, visits to parks, transit stations, workplaces, and grocery and pharmacy units dropped by 68%, 66%, 41%, and 51%, respectively. On the other hand, visits to residential places increased by 22% as people largely stayed home during the lockdown (Kawoosa, 2020). Hindustan Times ranked states and Union territories on their average decrease in mobility to non-residential places. The states have the highest drop in overall mobility are Chandigarh (85%), Delhi (82%), and Andaman and Nicobar Islands (71%) and Maharashtra (71%) and the lowest drop showed in Mizoram (34%), Arunachal Pradesh (39%), Bihar (41%) and Manipur (41%) (Kawoosa, 2020).

This study intends to give insights into what has changed in response to policies aimed at combating COVID-19 in upcoming days. To analyze the impact of COVID-19 lockdown on community mobility trends using Spatio time-series change across different states and UTs of India. This study also figures out mobility trends over time during pre lockdown and after lockdown period across different categories of places such as retail and recreation, groceries and pharmacies, parks, transit stations, workplaces, and residential, which can be used in public health strategies to drop the spread of COVID-19.

Table 1

| States & Union Territories | Retail & recreational mobility | | | | | |
|---------------------------|-------------------------------|---|---|---|---|---|
|                           | Pre lockdown (% change from baseline) | During lockdown (% change from baseline) | Decrease (pre and during lockdown) |
|                           | 15th February | 29th February | 18th March | Average | 31st March | 15th April | 30th April | Average | |
| Andaman and Nicobar Islands | 1.0 | -1.0 | -21.0 | -7.0 | -72.0 | -82.0 | -86.0 | -90.0 | -73.0 | |
| Andhra Pradesh | -1.0 | -1.0 | -4.0 | -2.0 | -72.0 | -77.0 | -85.0 | -78.0 | -76.0 | |
| Arunachal Pradesh | 1.0 | 0.0 | -9.0 | -2.7 | -62.0 | -68.0 | -70.0 | -66.7 | -64.0 | |
| Assam | 2.0 | 0.0 | -2.0 | 0.0 | -71.0 | -74.0 | -82.0 | -75.7 | -75.7 | |
| Bihar | 4.0 | 4.0 | -2.0 | 2.0 | -52.0 | -64.0 | -78.0 | -68.0 | -64.0 | |
| Chandigarh | 0.0 | -7.0 | -15.0 | -7.3 | -80.0 | -92.0 | -94.0 | -92.0 | -84.7 | |
| Chhattisgarh | 1.0 | -3.0 | 5.0 | 1.0 | -69.0 | -71.0 | -77.0 | -72.3 | -73.3 | |
| Dak Lak and Nagar | 5.0 | 4.0 | 2.0 | 3.7 | -70.0 | -71.0 | -72.0 | -71.0 | -74.7 | |
| Daman and Diu | 5.0 | 1.0 | -4.0 | 0.7 | -74.0 | -81.0 | -81.0 | -78.7 | -79.3 | |
| Delhi | 1.0 | -13.0 | -15.0 | -9.0 | -84.0 | -87.0 | -89.0 | -86.7 | -77.7 | |
| Goa | -2.0 | -7.0 | -23.0 | -10.7 | -76.0 | -77.0 | -75.0 | -76.0 | -76.0 | |
| Gujarat | 0.0 | -4.0 | -9.0 | -4.3 | -79.0 | -82.0 | -87.0 | -82.7 | -78.3 | |
| Haryana | 3.0 | -7.0 | -8.0 | -4.0 | -73.0 | -76.0 | -82.0 | -77.0 | -73.0 | |
| Himachal Pradesh | 9.0 | -8.0 | -3.0 | -6.7 | -63.0 | -66.0 | -72.0 | -67.0 | -66.3 | |
| Jammu and Kashmir | 166.0 | 59.0 | 229.0 | 151.3 | 6.0 | -6.0 | -29.0 | -6.7 | -158.0 | |
| Jharkhand | -1.0 | 0.0 | 0.0 | -0.3 | -64.0 | -68.0 | -81.0 | -71.0 | -70.7 | |
| Karnataka | 2.0 | 3.0 | -18.0 | -4.3 | -79.0 | -81.0 | -83.0 | -81.0 | -76.7 | |
| Kerala | -3.0 | -5.0 | -23.0 | -10.3 | -76.0 | -79.0 | -83.0 | -79.3 | -69.0 | |
| Lakshadweep | 2.0 | -2.0 | -8.0 | -2.7 | -74.0 | -76.0 | -83.0 | -77.7 | -75.0 | |
| Madhya Pradesh | -3.0 | -5.0 | -22.0 | -10.0 | -80.0 | -82.0 | -87.0 | -83.0 | -73.0 | |
| Maharashtra | 1.0 | 0.0 | 0.0 | 0.3 | -51.0 | -70.0 | -81.0 | -67.7 | -67.3 | |
| Meghalaya | 13.0 | -66.0 | 13.0 | -11.3 | -64.0 | -78.0 | -79.0 | -65.0 | -53.7 | |
| Mizoram | 4.0 | 19.0 | -1.0 | 7.3 | -60.0 | -72.0 | -83.0 | -74.0 | -81.3 | |
| Nagaland | 1.0 | -1.0 | 0.0 | 0.0 | -57.0 | -74.0 | -78.0 | -69.7 | -69.7 | |
| Noida | -1.0 | -0.0 | -14.0 | -5.0 | -71.0 | -74.0 | -81.0 | -75.3 | -70.3 | |
| Puducherry | -1.0 | -1.0 | -12.0 | -4.7 | -81.0 | -87.0 | -86.0 | -84.7 | -86.0 | |
| Punjab | 1.0 | -7.0 | -8.0 | -4.7 | -77.0 | -78.0 | -83.0 | -79.3 | -74.7 | |
| Rajasthan | 2.0 | -1.0 | -8.0 | -2.3 | -73.0 | -74.0 | -81.0 | -76.0 | -73.7 | |
| Sikkim | 6.0 | 15.0 | 1.0 | 7.3 | -56.0 | -65.0 | -76.0 | -65.7 | -73.0 | |
| Tamil Nadu | 1.0 | 3.0 | -13.0 | -3.0 | -77.0 | -82.0 | -84.0 | -81.0 | -78.0 | |
| Telangana | 2.0 | 3.0 | -10.0 | -1.7 | -81.0 | -84.0 | -89.0 | -84.7 | -83.0 | |
| Tripura | 3.0 | 1.0 | -7.0 | -2.3 | -65.0 | -70.0 | -81.0 | -72.0 | -69.3 | |
| Uttar Pradesh | 4.0 | -2.0 | -7.0 | -1.7 | -68.0 | -70.0 | -82.0 | -73.3 | -71.7 | |
| Uttarakhand | 5.0 | -5.0 | -6.0 | -2.0 | -69.0 | -70.0 | -78.0 | -72.3 | -70.3 | |
| West Bengal | -3.0 | -3.0 | -10.0 | -5.3 | -69.0 | -72.0 | -86.0 | -75.7 | -70.3 | |

India | 6.6 | -1.0 | -4.9 | 1.6 | -68.3 | -73.7 | -79.7 | -73.9 | -73.4 |
2. Operational definitions of place categories for community mobility trends

This study contains different categories of places that are used for showing community mobility trends are:

i) Retail & recreational mobility: Mobility towards places like restaurants, cafes, shopping centers, museums, libraries, and picture theaters are named as retail & recreational mobility; ii) Grocery & pharmacy mobility: Daily or sometimes weekly mobility trends for places viz. grocery, food warehouses, markets, local hats, farmer’s markets, specialty food shops, different drug or medicine stores, and pharmacies (Google, 2020); iii) Parks mobility: Mobility trends for places of attraction like local parks, national parks, public beaches, marinas, dog parks, plazas, and public gardens; iv) Transit stations mobility: This mobility refers to the process by which a person moves from one place to another place like public transport hubs such as subway, bus, and train stations. v) Workplaces mobility: This type of mobility trends for going places of work from a native place; and vi) Residential mobility: Mobility in the direction of places of residence where a person lived (Google, 2020).

3. Materials and methods

3.1. Study design and period

“COVID-19 Community Mobility Report’ was prepared by Google in 2020. A daily time-series data was gathered using location and highlight the percentage of changes for each day from the baseline value and data collection started from 15th February 2020 to onwards before and during the COVID-19 lockdown period in India.

3.2. Data source of the study and coverage

For this research, data is used from the ‘Google COVID-19 Community Mobility Reports’, 2020, consisting of state and union territories (UTs) wise daily time-series community mobility data. This data is collected by counting the number of requests made to Google maps for directions in choose countries, sub-regions, and cities and also the accessibility of data in a particular country, sub-region, or city is based on many factors, as well as minimum thresholds for direction requests per day (Google, 2020). To evaluate the COVID-19 lockdown impact on different types of the mobility of people in India, data covering all the states and UTs have been utilized to fulfill the objective. The report from Google is to provide insights into what has changed in response to policies proposed at combating the COVID-19 pandemic situation over the World as well as in India (Chan et al., 2020; Kraemer et al., 2020; Chan, Skali, & Torgler, 2020; Fitzpatrick and DeSalvo, 2020; Google, 2020). This report is also helpful for highlighting public health strategies, like the measure of social distancing, to slow the transmission rate. The reports mobility data trends over time from 15th February to currently onwards, throughout different types of places like retail and recreation, groceries and pharmacies, parks, transit stations, ...
workplaces, and residential in India (Google, 2020). This dataset is likely to assist in remediating the impact of COVID-19, presented by location, and highlights the percentage of changes for each day (increase or decrease) from the baseline value for that day of the week in visits to places like grocery and pharmacy stores, workplaces, and parks, etc. within a geographic region.

However, the present study has been prepared based on state & UTs wise time-series data that included the daily percentage of changing from baseline for retail and recreational mobility, groceries and pharmacies mobility, parks mobility, transit stations, workplaces, and residential mobility in India from 15th February 2020 to 30th April 2020. The data used in this study is available in the public domain (https://www.google.com/covid19/mobility/).

### 3.3. Methods

This research used exploratory data analysis to provide insights into how the Indian people move before and during the lockdown period. To show, the average percentage change in various community mobility for the pre-lockdown and during-lockdown period of COVID-19 pandemic, time-series data has been classified into two-time frame i.e. pre lockdown (dates include 15th February, 29th February, and 18th March) and during lockdown period (dates include 31th March, 15th April, and 30th April). After that, the average percentage change of mobility during pre-lockdown and the after-lockdown period has been calculated, next subtracting the average change of mobility at the pre-lockdown period from the lockdown period using Microsoft Excel Workbook. Conditional formatting techniques have been performed with selecting all cells of pre-lockdown and during lockdown period using color scales or color ramps (Green, Yellow, and Red) to display color gradient in a range of selected cells. The shade of the color represents the value i.e. the percentage change from baseline in the selected cells. Among all types of community mobility except residential mobility green color indicates the very low percentage of mobility decreased from baseline, yellow color indicates the moderate percentage of decreased, and red color indicates a high percentage of decreased mobility form baseline. In the case of residential mobility, the color ramps in the cells represent quite opposite because of after lockdown, only residential mobility percentage has been increased from baseline as people generally stayed in their dwellings during the lockdown period in India.

To show state-wise daily change of different community mobility for the pre-lockdown and during lockdown period of COVID-19 pandemic, time-series data has been divided into two-time frame i.e. pre lockdown period (from 15th February to 23rd March 2020) and during lockdown period (from 24th March to 30th April 2020). After that using mobility data, suitable line graphs have been plotted for each state and UTs in India. To depict, change in the spatial pattern of various community mobility for the pre-lockdown (15th February and 18th March 2020) and during the lockdown period (25th March, 26th March, 28th March, 31th March, 2nd April, 10th April, and 30th April), inverse distance weighted (IDW) interpolation mapping techniques have been utilized.

#### Table 2

| States & Union Territories | Grocery & pharmacy mobility | | |
|---------------------------|-------------------------------|----------------|----------------|
|                           | Pre lockdown (% change from baseline) | During lockdown (% change from baseline) | Decrease (pre and during lockdown) |
|                           | 15th February | 29th February | 18th March | Average | 31st March | 15th April | 30th April | Average | |
| Andaman and Nicobar Islands | -9.0 | -19.0 | -20.0 | -16.0 | -64.0 | -64.0 | -48.0 |
| Andhra Pradesh | -1.0 | -1.0 | 2.0 | 0.0 | -56.0 | -46.0 | -42.0 | -48.0 |
| Arunachal Pradesh | -9.0 | -6.0 | -3.0 | -6.0 | -62.0 | -44.0 | -31.0 | -45.7 |
| Assam | 3.0 | 3.0 | 4.0 | 3.3 | -68.0 | -55.0 | -41.0 | -54.8 |
| Bihar | 5.0 | 9.0 | 6.0 | 8.7 | -55.0 | -35.0 | -18.0 | -36.0 |
| Chandigarh | 0.0 | -14.0 | -4.0 | -6.0 | -84.0 | -81.0 | -82.0 | -82.3 |
| Chhattisgarh | 2.0 | -3.0 | 1.0 | 0.0 | -60.0 | -40.0 | -20.0 | -40.0 |
| Dadra and Nagar Haveli | -25.0 | -28.0 | -35.0 | -26.3 | -66.0 | -49.0 | -2.0 | -39.0 |
| Daman and Diu | -5.0 | -10.0 | 5.0 | -3.3 | -67.0 | -57.0 | -44.0 | -56.0 |
| Delhi | 2.0 | 15.0 | -1.0 | -4.7 | -74.0 | -68.0 | -66.0 | -69.3 |
| Goa | -7.0 | -12.0 | -8.0 | -9.0 | -70.0 | -57.0 | -45.0 | -57.3 |
| Gujarat | 1.0 | 0.0 | -1.0 | 0.0 | -67.0 | -59.0 | -54.0 | -60.0 |
| Haryana | 3.0 | -11.0 | 2.0 | -2.0 | -65.0 | -54.0 | -33.0 | -54.0 |
| Himachal Pradesh | 8.0 | -12.0 | 2.0 | -0.7 | -61.0 | -50.0 | -33.0 | -48.0 |
| Jammu and Kashmir | 153.0 | 54.0 | 233.0 | 146.7 | 4.0 | 44.0 | 91.0 | 46.3 |
| Jharkhand | -1.0 | -1.0 | 7.0 | 1.7 | -62.0 | -49.0 | -41.0 | -50.7 |
| Karnataka | 1.0 | 2.0 | -1.0 | 0.7 | -38.0 | -30.0 | -41.0 | -49.7 |
| Kerala | -2.0 | -2.0 | -7.0 | -3.7 | -63.0 | -41.0 | -27.0 | -43.7 |
| Lakshadweep | 3.0 | 0.0 | 0.0 | 1.0 | -69.0 | -54.0 | -46.0 | -56.3 |
| Madhya Pradesh | 1.0 | 0.0 | -5.0 | -2.0 | -64.0 | -53.0 | -52.0 | -56.3 |
| Maharashtra | -1.0 | -3.0 | -1.0 | -1.7 | -60.0 | -51.0 | -25.0 | -45.3 |
| Meghalaya | 19.0 | -68.0 | 2.0 | -14.3 | -55.0 | -76.0 | -48.0 | -59.7 |
| Mizoram | 10.0 | 15.0 | 4.0 | 9.7 | -56.0 | -46.0 | -32.0 | -48.0 |
| Nagaland | -8.0 | -5.0 | -1.0 | -4.7 | -72.0 | -69.0 | -52.0 | -64.3 |
| Odisha | 0.0 | -1.0 | -1.0 | -0.7 | -64.0 | -46.0 | -39.0 | -49.7 |
| Puducherry | 7.0 | -7.0 | 6.0 | 1.3 | -72.0 | -58.0 | -40.0 | -60.0 |
| Punjab | 2.0 | -8.0 | 3.0 | -1.0 | -70.0 | -57.0 | -48.0 | -58.3 |
| Rajasthan | 2.0 | 0.0 | 0.0 | 0.7 | -63.0 | -46.0 | -34.0 | -47.7 |
| Sikkim | 16.0 | 21.0 | -5.0 | 10.7 | -71.0 | -63.0 | -61.0 | -65.0 |
| Tamil Nadu | 0.0 | 1.0 | 10.0 | 3.7 | -61.0 | -51.0 | -32.0 | -48.0 |
| Telangana | 0.0 | 2.0 | 5.0 | 2.3 | -60.0 | -52.0 | -49.0 | -53.7 |
| Tripura | 9.0 | 1.0 | 10.0 | 3.7 | -54.0 | -46.0 | -28.0 | -42.7 |
| Uttarakhand | 6.0 | -1.0 | 4.0 | 3.0 | -60.0 | -42.0 | -36.0 | -46.0 |
| West Bengal | 1.0 | 2.0 | 2.0 | 1.7 | -60.0 | -48.0 | -38.0 | -48.7 |
| India | 5.1 | -3.3 | 7.1 | 2.6 | -62.0 | -49.9 | -36.7 | -50.0 |

This dataset is likely to assist in remediating the impact of COVID-19, presented by location, and highlights the percentage of changes for each day (increase or decrease) from the baseline value for that day of the week in visits to places like grocery and pharmacy stores, workplaces, and parks, etc. within a geographic region.
4. Results and Discussion

4.1. Changes in retail & recreational mobility for the pre-lockdown and during-lockdown period of COVID-19 pandemic

Table 1 represents changes in retail & recreational mobility for the pre-lockdown and during-lockdown period of the COVID-19 pandemic in India. Across India, retail and recreational mobility dropped by −73.3% (Fig. 1) from the baseline average. The states which have the highest drop (up to 30th April) in retail and recreational mobility after COVID-19 lockdown are Chandigarh (−84.7%), Telangana (−83%), Mizoram (−81.3%), Puducherry (−80%), Daman and Diu (−79.3%), Delhi (−77.7%), Andhra Pradesh (−76%), Andaman and Nicobar Islands (−73%) and Maharashtra (−73%) (Fig. 1). The states which have the lowest drop showed in retail and recreational mobility are Meghalaya (−53.7%), Arunachal Pradesh (−64%), Goa (−65.3%), and Himachal Pradesh (−66.3%) (Fig. 1). The shade of the color represents the value i.e. the percentage change from baseline in the selected cells. After lockdown started, retail & recreational mobility dropped, for that very reason, during lockdown days all cells showed in red to light red color indicates a high percentage of decreased in mobility form baseline except Jammu and Kashmir because of internet services were not active throughout the year, which can create incorrect results. In Google’s report as Jammu and Kashmir has shown a flow in visits to transit stations and workplaces during the lockdown of COVID-19, which is quite different to the real ground situation (Google, 2020; Kawoosa, 2020).

4.2. Changes in grocery & pharmacy mobility for the pre-lockdown and during-lockdown period of COVID-19 pandemic

Table 2 represents changes in grocery and pharmacy mobility for the pre-lockdown and during-lockdown period of the COVID-19 pandemic in India. Across India, grocery and pharmacy mobility dropped by −51.2% (Fig. 1) from the baseline average. The states which have the highest drop (up to 30th April) in retail and grocery and pharmacy mobility after COVID-19 lockdown are Chandigarh (−76.3%), Sikkim (−75.7%), Delhi (−64.7%), Gujarat (−60%), Nagaland (−59.7%) (Fig. 1). The states which have the lowest drop showed in grocery and pharmacy mobility are Arunachal Pradesh (−39.7%), Chhattisgarh (−40%), Kerala (−40%), Bihar (−42.7%), Manipur (−43.7%) (Fig. 1). After lockdown started, grocery and pharmacy mobility dropped, so, it is shown in Table 2 that, during lockdown existence, all cells showed in red to light red color indicates a high percentage of decreased in grocery and pharmacy mobility form baseline percentage compared to pre-lockdown period, the cells yellow color indicates a normal situation of daily mobility of community or individual in India.

4.3. Changes in parks mobility for the pre-lockdown and during-lockdown period of COVID-19 pandemic

Table 3 represents changes in park mobility for the pre-lockdown and during-lockdown period of COVID-19 pandemic.
and during-lockdown period of the COVID-19 pandemic in India. Across India, park mobility dropped by −46.3% (Fig. 1) (up to 30th April) from the baseline average. The states which have the highest drop (up to 30th April) in park mobility after COVID-19 lockdown are Chandigarh (−90.3%), Delhi (−80.3%), Puducherry (−82%), Daman and Diu (−74%), Haryana (−69%), and −65% in Rajasthan (Fig. 1). The states which have lowest drop showed in park mobility are Lakshadweep (−7.7%), Meghalaya (−8.3%), Himachal Pradesh (−13%), Tripura (−16%), Manipur (−17.3%), Arunachal Pradesh (17.3%), and Bihar (−21.7%) (Fig. 1). In north-east states of India have shown lowest drop because of mountainous environment, in Kerala drop showed low for decreasing COVID-19 confirmed cases but in Bihar, Jharkhand, and Odisha due to lack of consciousness of people, drop-in park mobility showed low in percentage from baseline average during lockdown (up to 30th April). After lockdown started, mobility towards for places like public transport hubs such as subway, bus, and train stations has been dropped, so, it is depicted in Table 4 that, during lockdown persistence, all cells are in red to light red color and light yellow color in some parts, except Jammu and Kashmir, indicates high to a moderately high percentage of decreased in park mobility form baseline percentage compared to pre-lockdown period, the cells yellow color indicates a normal situation of daily park mobility of people or individual in India.

4.4. Changes in transit stations mobility for the pre-lockdown and during-lockdown period of COVID-19 pandemic

Table 4 represents changes in transit station mobility for the pre-lockdown and during-lockdown period of the COVID-19 pandemic in India. Across India, transit station mobility dropped by −66% (Fig. 1) (up to 30th April, 2020) from the baseline average. The states which have the highest drop (up to 30th April) in transit stations mobility after COVID-19 lockdown are Chandigarh (−83.7%), Delhi (−77.7%), Sikkim (−74%), Uttar Pradesh (−72.3%), Maharashtra (−71.3%), and Haryana (−70.7%), indicates in red color (Table 4). The states which have the lowest drop showed in transit stations mobility are Meghalaya (−59.0%), Kerala (−45.3%), Himachal Pradesh (−43.6%), Arunachal Pradesh (−49.3%), Manipur (−50.3%), and Goa (−51.7%) (Fig. 1), indicates in light red color (Table 4). After lockdown started, mobility towards for places like public transport hubs such as subway, bus, and train stations has been dropped, so, it is depicted in Table 4 that, during lockdown persistence, all cells are in red to light red color and light yellow color in some parts, except Jammu and Kashmir, depicts high to a moderately high percentage of decreased in transit stations mobility form baseline percentage compared to pre-lockdown period, the cell values with yellow color indicates a normal situation of daily transit stations mobility of person in India.

Table 4

| States & Union Territories | Transit stations mobility | Decreas e (pre and during lockdown) |
|-----------------------------|---------------------------|-----------------------------------|
|                             | Pre lockdown (% change from baseline) | During lockdown (% change from baseline) |
|                             | 15th February | 29th March | Average | 31st March | 15th April | 30th April | Average |
| Andaman and Nicobar Islands | -2.0 | -5.0 | -14.0 | -7.0 | -60.0 | -75.0 | -80.0 | -71.7 | -64.7 |
| Andhra Pradesh              | 5.0 | 1.0 | -3.0 | 1.0 | -64.0 | -58.0 | -58.0 | -60.0 | -61.0 |
| Arunachal Pradesh           | -4.0 | -4.0 | 3.0 | -1.7 | -43.0 | -55.0 | -55.0 | -51.0 | -49.3 |
| Assam                       | 1.0 | 0.0 | 2.0 | 1.0 | -72.0 | -65.0 | -59.0 | -65.3 | -66.3 |
| Bihar                       | 6.0 | 6.0 | 4.0 | 5.3 | -66.0 | -62.0 | -57.0 | -61.7 | -57.0 |
| Chandigarh                  | 4.0 | -3.0 | -8.0 | -2.3 | -89.0 | -86.0 | -83.0 | -86.0 | -83.7 |
| Chhattisgarh                | 6.0 | 2.0 | -4.0 | 1.3 | -73.0 | -68.0 | -63.0 | -68.0 | -69.3 |
| Dadra and Nagar Haveli      | 0.0 | -16.0 | 4.0 | -4.0 | -71.0 | -67.0 | -75.0 | -71.0 | -57.0 |
| Daman and Diu               | 12.0 | -5.0 | 3.0 | -2.7 | -71.0 | -66.0 | -69.0 | -62.0 | -55.0 |
| Goa                         | 6.0 | -5.0 | -20.0 | -8.3 | -86.0 | -84.0 | -82.0 | -84.0 | -77.7 |
| Gujarat                     | 2.0 | -2.0 | -8.0 | -2.7 | -71.0 | -63.0 | -61.0 | -65.0 | -52.3 |
| Haryana                     | 5.0 | -2.0 | -13.0 | -3.3 | -77.0 | -74.0 | -71.0 | -74.0 | -70.7 |
| Himachal Pradesh            | 9.0 | -1.0 | 6.0 | 4.7 | -71.0 | -63.0 | -61.0 | -63.0 | -61.7 |
| Jammu and Kashmir           | 249.0 | 102.0 | 392.0 | 247.7 | 72.0 | 102.0 | 139.0 | 104.3 | -143.3 |
| Jharkhand                   | 4.0 | -7.0 | 6.0 | 5.7 | -57.0 | -63.0 | -65.0 | -63.0 | -65.0 |
| Karnataka                   | 3.0 | 3.0 | -15.0 | -3.0 | -70.0 | -61.0 | -58.0 | -63.0 | -60.0 |
| Kerala                      | -3.0 | -5.0 | -20.0 | -9.3 | -66.0 | -52.0 | -66.0 | -54.7 | -45.3 |
| Lakeshawdeep                | 4.0 | 1.0 | -5.0 | 0.0 | -74.0 | -66.0 | -64.0 | -68.0 | -68.0 |
| Madhya Pradesh              | 3.0 | 0.0 | -19.0 | -5.3 | -80.0 | -75.0 | -75.0 | -76.0 | -71.3 |
| Manipur                     | 7.0 | 3.0 | 3.0 | 4.3 | -59.0 | -45.0 | -34.0 | -46.0 | -50.3 |
| Meghalaya                   | 1.0 | -53.0 | 5.0 | -16.3 | -52.0 | -58.0 | -32.0 | -47.3 | -31.0 |
| Mizoram                     | 4.0 | 25.0 | 7.0 | 13.3 | -61.0 | -40.0 | -37.0 | -46.0 | -59.3 |
| Nagaland                    | 1.0 | 0.0 | 11.0 | 4.0 | -64.0 | -69.0 | -61.0 | -64.7 | -58.7 |
| Odisha                      | 4.0 | 3.0 | -3.0 | 1.3 | -70.0 | -62.0 | -59.0 | -63.7 | -55.0 |
| Puducherry                  | 5.0 | 2.0 | -7.0 | 0.0 | -67.0 | -57.0 | -47.0 | -57.0 | -57.0 |
| Punjab                      | 3.0 | -4.0 | -6.0 | -2.3 | -75.0 | -70.0 | -69.0 | -71.3 | -59.0 |
| Rajasthan                   | 4.0 | 4.0 | -5.0 | 1.0 | -72.0 | -66.0 | -62.0 | -66.7 | -57.7 |
| Sikkim                      | 7.0 | 4.0 | -7.0 | 1.3 | -69.0 | -80.0 | -69.0 | -72.7 | -74.0 |
| Tamil Nadu                  | 2.0 | 3.0 | -7.0 | -0.7 | -68.0 | -60.0 | -56.0 | -61.3 | -60.7 |
| Telangana                   | 4.0 | 4.0 | -4.0 | 1.3 | -75.0 | -68.0 | -69.0 | -70.7 | -72.0 |
| Tripura                     | 5.0 | 1.0 | 7.0 | 4.3 | -70.0 | -55.0 | -54.0 | -63.0 | -57.5 |
| Uttar Pradesh               | 5.0 | 1.0 | -5.0 | 0.3 | -75.0 | -71.0 | -70.0 | -72.0 | -72.3 |
| Uttarakhand                 | 13.0 | 3.0 | 6.0 | 7.3 | -66.0 | -59.0 | -58.0 | -61.0 | -58.3 |
| West Bengal                 | -1.0 | 0.0 | -6.0 | -2.3 | -76.0 | -70.0 | -68.0 | -71.3 | -69.0 |
| India                       | 10.7 | 1.8 | 7.5 | 6.7 | -64.8 | -59.5 | -53.8 | -59.4 | -66.0 |
4.5. Changes in workplaces mobility for the pre-lockdown and during-lockdown period of COVID-19 pandemic

Table 5 represents changes in workplaces mobility for the pre-lockdown and during-lockdown period of COVID-19 lockdown in India, 2020. Across India, workplaces mobility dropped by $-56.7\%$ (Fig. 1) (up to 30th April, 2020) from the baseline average during the lockdown. The states which have the highest drop (up to 30th April) in workplaces mobility after COVID-19 lockdown are Delhi ($-81.3\%$), Chandigarh ($-77.3\%$), Maharashtra ($-71\%$), Gujarat ($-71\%$), Karnataka and Haryana ($-69\%$ in both states), Telangana ($-68\%$), Punjab ($-67\%$) (Fig. 1). The states which have the lowest increase (up to 30th April) in residential mobility after COVID-19 lockdown are Mizoram ($-0.3\%$), Himachal Pradesh (0\%), Manipur (0.7\%), Bihar (43.7\%), Trivandrum (42.3\%), and Sikkim ($-44.7\%$) (Fig. 1). After lockdown started, mobility trends towards workplaces have been decreased, so, it is cleared to show in Table 4 that, during lockdown persistence all cells are in red to light red color and in some states of UTs have a light yellow color, except Jammu and Kashmir which depicts high to a moderately high percentage of dropped in workplaces mobility form baseline percentage compared to the pre-lockdown period (15th February, 29th February, and 18th March). The cell values with yellow color indicate a normal situation (pre-lockdown phase) of daily mobility towards workplaces of the community or a person of states and UTs of India.

4.6. Changes in residential mobility for the pre-lockdown and during-lockdown period of COVID-19 pandemic

Table 6 represents changes in residential mobility for the pre-lockdown and during-lockdown period of the COVID-19 pandemic in India. Across India, residential mobility increased by $23.8\%$ (Fig. 1) (up to 30th April, 2020) from the baseline average during the lockdown as people mostly stayed home during the lockdown. The states which have the highest increase (up to 30th April) in residential mobility after COVID-19 lockdown are Chandigarh (34.7\%), Gujarat (33\%), Puducherry (33\%), Delhi (32.3\%), Maharashtra (32\%), Tamil Nadu (32\%), Telangana (31\%), Karnataka (30\%), Haryana (29.3\%), Sadar and Nagar Haveli (29.3\%) (Fig. 1). The states which have the lowest increase in residential mobility showed in residential mobility are Mizoram ($-13.3\%$), Himaical Pradesh (17.7\%), Manipur (13.7\%), Sikkim (14.3\%), Mizoram (15\%), Nagaland (15.7\%), Bihar (16.3\%), Himachal Pradesh (17.7\%), and Tripura (19\%) (Fig. 1). In north-east states of India have shown lowest increase because of mountainous environment and in pre-lockdown period i.e. in normal situation residential mobility was also predominantly lowest from the baseline because of mountainous relief i.e. in pre-lockdown period residential mobility was Mizoram ($-0.3\%$), Himachal Pradesh (0\%), Manipur (0.7\%), Sikkim (0.7\%), Arunchal Pradesh (0.7\%), Nagaland (1\%), and Tripura (1\%).
4.7. Average changes in community mobility for the pre-lockdown and during-lockdown period of COVID-19 pandemic

4.7.1. State & union territory wise daily change of different community mobility for the pre-lockdown and during lockdown period of COVID-19 pandemic in India

Fig. 2 depicts, that states and UTs wise daily change of community mobility at the pre-lockdown (from 15th February to 23rd March 2020) and during lockdown period (started from 24th March to 30th April 2020) of COVID-19 pandemic in India. Visits to parks, transit stations, workplaces, and grocery and pharmacy mobility units have been dropped, on the other hand, visits to residential places or homes have been increased for the lockdown (up to 30th April 2020). After lockdown started, retail and recreational mobility has been drastically dropped but after April 15 retail and recreational mobility has been drastically dropped throughout the states and UTs of India. Before lockdown started, across India and all over the states and UTs in India different types of community mobility has been dropped due to announcement of Indian government “Janata Curfew” successfully practiced on 22nd March, 2020 for requesting citizens to remain at home for a day in an attempt to end the spread of the deadly disease, the restore to health for which has not yet been developed (Press Trust of India (PTI), 2020). After lockdown started, towards park mobility has been dropped but after April 15 park mobility has been hugely dropped throughout in India.

4.8. Spatial pattern of retail & recreational mobility for the pre-lockdown and during the lockdown period

Fig. 3 depicts the state & union territory wise spatial change in retail & recreational mobility during pre-lockdown and post-lockdown days between 15th February and 30th April, 2020. As stated before the COVID-19 lockdown started on 24 March 2020 and just gone one day (25th of March) of the beginning of lockdown, there is a decrease in percentage (-70.51%) of retail and recreational mobility from baseline in distinction to the pre-lockdown period. About −70%, −70.2%, −68.26%, −69.83%, −74.09%, and −79.69% of the decrease in retail and recreational mobility from baseline are observed on 26th March, 28th March, 31th March, 2nd April, 10th April, and 30th April, 2020 in India respectively. This reduction in retail & recreational mobility from baseline is more likely associated with the starting lockdown on 24th March due to COVID-19 pandemic over all states and UTs of India. This figure also depicts, after lockdown started, mobility has been decreased from very low (green color to yellow) to moderately high (yellow color to red over states and UTs of India. Up to 30th April, very low mobility was found in the states like- Andaman and Nicobar Island (−86% decreased from baseline), Andhra Pradesh (−85%), Chandigarh (−94%), Delhi (−89%), Gujarat (−87%), Maharashtra (−87%), Puducherry (−86%), Telangana (−89%), and West Bengal (−86%) and in the north-eastern states of India mobility is low compared to the states have very low mobility in India.
4.9. Spatial pattern of grocery and pharmacy mobility for the pre-lockdown and during the lockdown period

Fig. 4 depicts the state & union territory wise spatial change in grocery and pharmacy mobility during pre-lockdown and post-lockdown days between 15th February and 30th April, 2020. The COVID-19 lockdown started on 24 March 2020 and just gone one day (25th of March) of the beginning of lockdown, there is a decrease in percentage (−64.26%) of grocery and pharmacy mobility form baseline in distinction to the pre-lockdown period (5.09% on 15th February, 7.06% in 18th March). An average decrease of grocery and pharmacy mobility from baseline days was decreased after lockdown started but this mobility is quite less decreased compared to the other community mobility except for residential mobility because of grocery, food warehouses, markets, local hats, farmer’s markets, food shops, different drug or medicine stores, and pharmacies are essential commodities for the human being. For that very reason, different states and UTs in India depicted as yellow to a red color i.e. low to moderately high. About −63.91%, −64.03%, −62.34%, −64.43%, −52.88%, and −36.71% of the decrease in grocery and pharmacy mobility from baseline are observed on 26th March, 28th March, 31th March, 2nd April, 10th April, and 30th April in India respectively. During the lockdown period on 28th March, all the states and UTs had experienced very low mobility except a few parts and Jammu and Kashmir. During pre lockdown (18th March) to post lockdown (25th March), mobility has been decreased drastically in the state Andaman and Nicobar Islands (−20% to −76% decreased from baseline), Assam (4% to −71%), Chandigarh (−4% to −89%), Delhi (−1% to −76%), Goa (−8% to −81%), Meghalaya (−2% to −76%), Nagaland (−1% to −73%), Puducherry (6% to −73%), Punjab (3 to −76%), Sikkim (−5% to −71%) and other states and UTs of India. After 10th April, grocery and pharmacy mobility has been quietly increased compared to previous lockdown days.

4.10. Spatial pattern of parks mobility for the pre-lockdown and during the lockdown period

Fig. 5 depicts the state & union territory wise spatial change in park mobility during pre-lockdown and post-lockdown days between 15th February and 30th April, 2020. This COVID-19 lockdown started on 24 March 2020 and just after one day later (March 25) of the beginning of lockdown, there is a decrease in percentage (−46.17%) of park mobility form baseline in distinction to the pre-lockdown period. In India −46.2%, −48.51%, −45.09%, −46.4%, −42.46%, and −44.83% of the decrease in park mobility from baseline are observed on 26th March, 28th March, 31th March, 2nd April, 10th April, and 30th April respectively. After lockdown imposed, mobility has been decreased except the eastern part and Jammu and Kashmir, and parts of Kerala state, where mobility has been moderately decreased from baseline up to 10th April. Up to 10th April, mobility towards places of attraction like local parks, national parks, public beaches, marinas, dog parks, plazas, and public gardens has been moderately decreased in the north-east states of India like Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura, but after 10th April, mobility has been highly decreased and in Jammu and Kashmir.

4.11. Spatial pattern of transit stations mobility for the pre-lockdown and during the lockdown period

Fig. 6 depicts the state & union territory wise spatial change in transit stations mobility during pre-lockdown and post-lockdown days
between 15th February and 30th April, 2020. The COVID-19 lockdown started and just after one day (25 March) of the start of lockdown, there is a decrease in percentage (−65.6%) of transit stations mobility from baseline compared to the pre-lockdown period. In India −70%, −70.2%, −68.26%, −69.83%, −74.09%, and −79.69% of decreased in transit stations mobility from baseline are observed on 26th March, 28th March, 31st March, 2nd April, 10th April, and 30th April respectively. Mobility towards public transport hubs such as subway, bus, and train stations have been decreased after lockdown compulsory over all states and UTs of India except 31st March. On March 31, mobility towards transit stations have been quietly increased from other days during lockdown period in the eastern and north-eastern part of India due to a low number of cases were found in these parts, the same situation was also found in Kerala.

4.12. Spatial pattern of workplaces mobility for the pre-lockdown and during the lockdown period

Fig. 7 depicts the state & union territory wise spatial change in workplaces mobility during pre-lockdown and post-lockdown days between 15th February and 30th April, 2020. After lockdown imposed in India and just after one day later (25th of March) of the starting of lockdown, there is a decrease in percentage (−60.03%) of workplace mobility from baseline compared to the pre-lockdown period. About −59.42%, −54.11%, −56.14%, −58%, −57.5%, and −44.72% of the decreased in workplace mobility from baseline are observed on 26th March, 28th March, 31st March, 2nd April, 10th April, and 30th April respectively in India. During pre lockdown (18th March) to post lockdown (25th March), workplace mobility has been decreased significantly in the state Chandigarh (−11% vs. −85%), Dadra and Nagar Haveli (−1% vs. −70%), Daman and Diu (−3% vs. 72%), Delhi (−10% vs. −85%), Goa (−11% vs. −76%), Gujarat (−4% to −76%), Haryana (−9% vs. −76%), Karnataka (−22% vs. −81%), Maharashtra (−18% vs. −81%), Punjab (−4% vs. −74%), Tamil Nadu (−6% vs. −75%),
Fig. 3. Change in retail & recreational mobility from 15th February to 30th April 2020 in India.

Fig. 4. Change in grocery and pharmacy mobility from 15th February to 30th April 2020 in India.
Fig. 5. Change in park mobility from 15th February to 30th April 2020 in India.

Fig. 6. Change in transit stations mobility from 15th February to 30th April 2020 in India.
Fig. 7. Change in workplaces mobility from 15th February to 30th April 2020 in India.

Fig. 8. Change (increase) in residential mobility from 15th February to 30th April 2020 in India.
Telangana (−12% vs. −79%) and other states and UTs except Bihar, Jharkhand, and north-eastern states of India. On 30th April, workplace mobility has been quietly increased (−60.03% on March 25 to −44.72% on April 30) compared to previous lockdown days in India. Up to 30th April, mobility towards workplaces has been moderately decreased in the north-east states of India like Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura, and the eastern states like Bihar, Jharkhand, and Odisha.

4.13. Spatial pattern of residential mobility for the pre-lockdown and during the lockdown period

Fig. 8 depicts the state & union territory wise spatial change in residential mobility during pre-lockdown and post-lockdown days between 15th February and 30th April, 2020. As stated before the COVID-19 lockdown started on 24 March 2020 and just gone one day (25th of March) of the beginning of lockdown, there is an increase in percentage (26.32%) of residential mobility form baseline in distinction to the pre-lockdown period. About 26.82%, 26.12%, 25.4%, 27.03%, 28.35%, and −24.51% of the increase in residential mobility from baseline are observed on 26th March, 28th March, 31th March, 2nd April, 10th April, and 30th April in India respectively. After lockdown initiated, up to 30th April, mobility towards residential places have been less increased in the north-eastern states of India and also eastern and extreme northern states of India. Visits to residential places mobility increased as people mostly stayed home during the lockdown period in India.

5. Conclusion

This study figures out mobility trends over time during pre-lockdown and after lockdown period across different categories of places such as retail and recreation, groceries and pharmacies, parks, transit stations, workplaces, and residential, which can be used in public health strategies to drop the spread of COVID-19. Therefore the results of the present article may help to combat the COVID-19 pandemic. It may also assist to think whether lockdown would be a measure to reduce social distancing among human beings and may reduce the spread of Coronavirus disease from region to other region extensively. In conclusion, public health officials, health workers find them useful in their work to end the spread of COVID-19 pandemic.

CRediT authorship contribution statement

Jay Saha: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Supervision, Validation, Visualization, Writing - original draft, Writing - review & editing.
Bikash Barman: Formal analysis, Data curation, Investigation, Methodology, Writing - original draft. Pradip Chouhan: Conceptualization, Supervision, Validation, Visualization, Writing - original draft.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.childyouth.2020.105160.

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