Population Mobility Patterns and Monitoring of COVID-19 Restriction Measures in Latvia

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Abstract: Compared to the spring, when the Covid-19 pandemic started and people honestly followed the precautionary measures, the behavior of the Latvian population has changed significantly. The majority of Latvians do not exercise caution, and their activity has returned to pre-Covid-19 levels this autumn, negatively affecting the epidemiological situation in the country, according to an analysis of population behavior. Within the research, the epidemiological statistics of Center for Disease Prevention and Control and Latvian Mobile Telephone (LMT) mobile network events were analyzed to determine the relationship between population activity and epidemiological situation in Latvia as a whole, as well as in each region. According to the performed analysis, it is possible to divide Latvia into two parts - municipalities that were active during the emergency situation and places where the greatest activity is observed before and after the emergency situation. It was concluded that mobile call activity during emergencies in both cities and counties is still high, it is 70% - 80% of the precrisis period. Since the spring, people's behavior and habits have changed significantly, so a different approach is needed.

1 INTRODUCTION

Compared with the spring when the Covid-19 pandemic started and people conscientiously followed the precautionary measures, the behaviour of the Latvian population has changed significantly. Analysis of population behaviour suggests that during the second wave of the pandemic at the end of 2020, the majority of Latvians do not exercise caution, and their activity has returned to pre-Covid-19 levels, negatively affecting the epidemiological situation in the country.

Already in the spring, when analysis of mobile data before and after the declaration of the emergency was performed (Arhipova, et al, 2019; Arhipova, et al, 2020), we found that most people followed the instructions to stay at home and it paid off – Latvia was globally recognized as a positive example of fighting the Covid-19 pandemic. This is probably one of the main reasons why we were able to enjoy summer holidays without restrictions. The autumn season started as usual – with increasing activity of the population. Unfortunately, the number of Covid-19 patients also increased.

The same problem was mentioned in another study (Ghanbari, 2020) suggesting that non-compliance with the intruduced restrictions contributed to the emergence of the second wave of the pandemic. The analysis of the spread of COVID-19 in ten biggest cities in the USA also shows that the population's inability to reduce their mobility resulted in high risk of infection in their respective locations and a model for detailed analysis for reducing the COVID-19 risk is developed (Chang, et al, 2020). Another study shows that the increase of confirmed cases of COVID-19 in some countries is critical and a new policy is needed to limit the spread of the virus (Mahmoudi, et al, 2020).

In the case of four countries, the problem of disease prediction in circumstances of incomplete or nonexistent information is considered and analysed using a fractal approach (Păcurar & Necula, 2020). Different strategies for reducing the spread of the virus have analysed various restrictive measures like

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social distancing and local lockdowns and their effectiveness in reducing the consequences of social isolation (Block, et al, 2020). In the framework of the research, the epidemiological statistics of Center for Disease Prevention and Control (SPKC, 2020) and Latvian Mobile Telephone (LMT) mobile network events were analysed to determine the relationship between population activity and epidemiological situation in Latvia as a whole, as well as specifically in various regions.

The purpose of the research is to assess the impact of various national and local restrictions on the control of Covid-19. The study has developed an approach to the processing of automated real-time data, which allows to take proactive actions and timely implementnecessary measures by the responsible authorities to control the spread of the virus.

The developed approach fully complies with the requirements of the General Data Protection Regulation (GDPR), at the same time allowing for an accurate assessment of population behaviour, such as the location, movement, and time of a specific activity.

2 POPULATION BEHAVIOUR ON SOCIO-ECONOMIC OBJECT LEVEL

The study analyses the aggregate statistics of LMT mobile network events in the period from October 2019 to December 2020, where network event data were aggregated by mobile network stations on a daily basis. It allows to use data on different aggregation levels, for example, an administrative region, city, town, or on a specific socio-economic infrastructure level like a supermarket.

Analysing the behaviour patterns of mobile activity over a year, from October 2019 to December 2020, allows us to recognize the most effective behavioural patterns of people responding to the implemented restrictions and warnings. It can be observed that the activity of the population at Riga's largest shopping centres in the autumn of 2020 has almost reached the level of 2019 in the respective period, unfortunately contributing to the spread of the disease and increasing the risk of Covid-19 for almost everyone (Fig. 1). Therefore, considering the good practices of several shopping centres and their ambitious efforts to introduce e-services, the society ought to rethink its "pre-pandemic" habits and increasingly use the opportunities to shop in the digital environment offered by retailers.

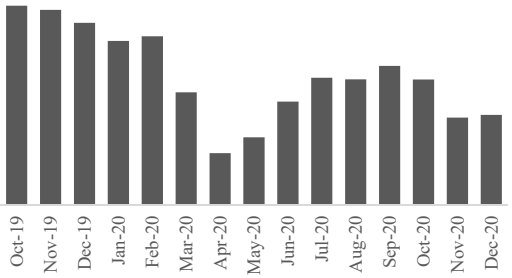

Figure 1: "Galeria Centrs" shopping centre average mobile phone day activity in Riga.

Figure 2 shows the mobile data activity pattern at one of Riga's supermarkets, Spice, which immediately and with great effect reacted to the restrictions in March - April 2020. The same pattern was observed at other socio-economic objects like theatres, museums, and corporate offices.

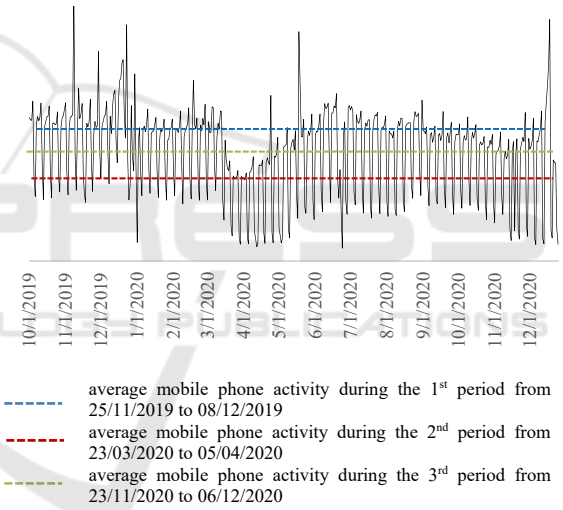

Figure 2: Mobile data activity pattern at Riga's supermarket, Spice.

Therefore, to monitor the effectiveness of the government decisions, restrictions and warnings, three two-week periods in the spring were used as a reference for behaviour patterns to understand the change of behaviour in October - November 2020.

Two full weeks were selected in the following periods: 1st period from 25/11/2019 to 08/12/2019 (corresponding period for the 3rd period), then 2nd period from 23/03/2020 to 05/04/2020 (the highest discipline point in complying with the restrictions) and 3rd period from 23/11/2020 to 06/12/2020 (after restrictions of the 2nd wave).

When comparing the behaviour patterns between the 3rd and the 2nd period, it was expected that mobile activity would drop to the level or near to the level of

the 2nd period. Instead, it remained on relatively high level – similar to the level of same period last year (1st period). The differences in mobile activity between the periods are even more visible when comparing the activity on weekdays for the periods (Fig. 3).

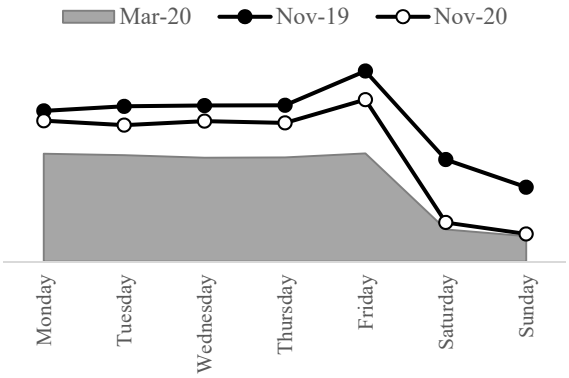

Figure 3: Mobile phone activity in the shopping centre, Spice, during weekdays.

The overall activity for the 3rd period is higher by 35 per cent on working days and by 16 per cent on weekends compared with the same weekdays in the 2nd period (spring lockdown). Due to specific restrictions effective on weekends, the activity on Saturdays and Sundays almost reaches the level of March - April 2020, but is higher on Fridays. Therefore, on micro (socio-economic object) level, the strategy of restriction implementation was more effective in the spring than in October - November 2020.

3 COMPARISON OF THE POPULATION MOBILITY IN MUNICIPALITIES BEFORE AND AFTER LOCKDOWN

According to the performed analysis, it is possible to divide Latvia into two parts – regions that were active during the emergency situation (Fig. 4.) and areas where the greatest activity was observed before and after the emergency situation (Fig. 5).

When comparing the situation in the capital city Riga with Engure and Saulkrasti regions, significant changes can be observed in the activity of the population. On 24 March 2020 (Tuesday) when the state of emergency was already in force in Latvia, the mobile call activity in Riga had decreased, returning to the previous level in September (Fig. 5), whereas in Engure and Saulkrasti municipalities, the population activity significantly increased after March and decreased in September (Fig. 4).

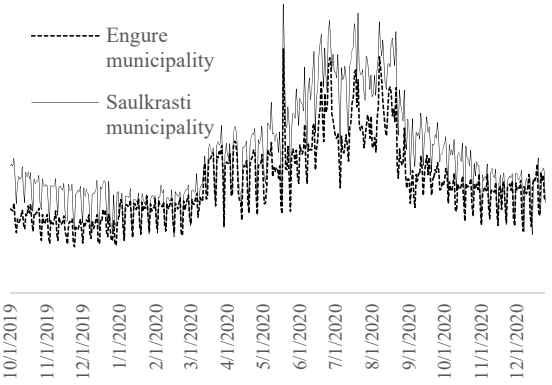

Figure 4: In Engure and Saulkrasti municipalities, mobile phone activities were higher during the emergency situation declared in March 2020.

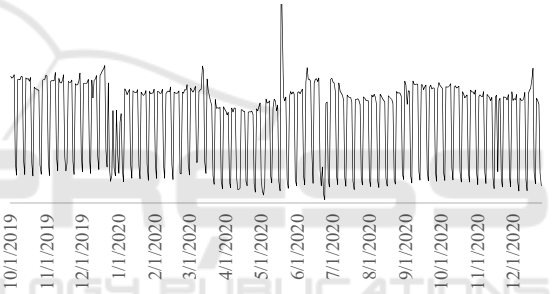

Figure 5: The city of Riga mobile phone activity before and after the emergency situation declared in March 2020.

Latvia's 119 municipalities were grouped according to the data of mobile phone activity and the Principal Component Analysis (PCA) was applied to evaluate mobility patterns. The first two principal components account for 46.6 % and 42.5 % respectively of the total variation. (Fig. 6).

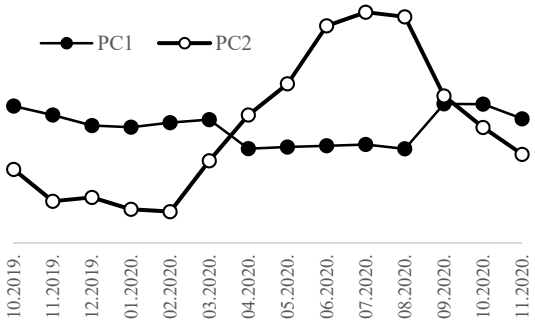

Figure 6: Principal components average values depending on months in 2019 - 2020.

The first principal component (PC) represents all municipalities with high mobile call activity until February 2020, low from March to August, and high from September to December 2020. The second PC represents other municipalities with high mobile activity patterns active during the lockdown time.

4 POPULATION FLOW MOBILITY ANALYSIS

Analysis of the information from mobile base stations helps identify the behavioural changes of the population from the beginning of lockdown, and monitor them later. The map shows the mobile phone activity on municipal level, with areas where the mobile activity is concentrated before lockdown (Fig. 7) and during lockdown (Fig. 8).

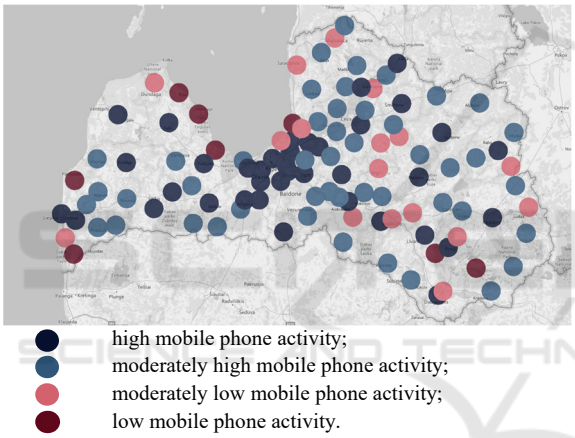

Figure 7: Mobile phone activity in Latvia municipalities before lockdown in January – March, 2020.

Before lockdown, normal business activity and, respectively, mobile phone activity is concentrated in the main areas of the economic activity like Riga city (in the centre of the map) and other larger cities. People from the neighbouring municipalities daily commute to Riga for work.

Following the introduction of lockdown in March 2020, people switched to remote work, and many employers provided the possibility to work from home. This affected the daily commuting patterns of people – the activity moved from large economic cantres to municipalities where people reside diminishing the need for daily commuting between different municipalities (Fig. 8).

Consequently, all mobile phone activity moved from city centres and business districts to residential areas. The changes in daily commuting patterns can be directly linked to the diminishing numbers of new Covid-19 cases in the respective period. In Latvia, commuting between municipalities is an important part of the economic activity pattern, especially for Riga city and its surrounding territories in the range of 100 km. Analysis of mobile phone activity allows monitoring daily commuting patterns related to on-site work and remote work. The maps (Fig. 7 and Fig. 8) show how population density in economically active areas is changing over time.

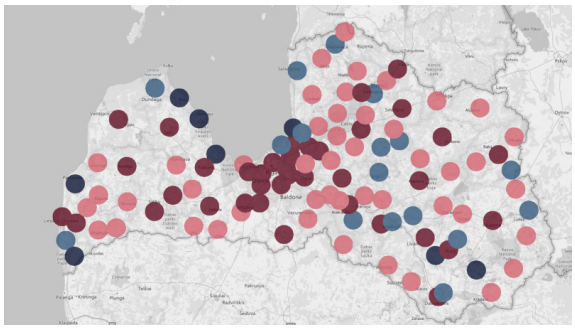

Figure 8: Mobile phone activity in Latvia municipalities during lockdown in March – June, 2020.

The data confirm that there is a direct link between the economic activity of the population and the prevalence of Covid-19, namely, the more active the population is, the higher the number of Covid-19 patients. The increase in the economic activity with a lag of about one month is reflected in the current Covid-19 statistics – the number of Covid-19 patients is growing rapidly.

Human contact is the major risk factor for the spread of Covid-19. The more physical contact there is among people, the greater the risk that neither social distancing nor facial masks and hand hygiene would help, as these principles are not always followed. It would be important to work remotely, reduce the movement of people, and avoid public gatherings and crowded places like sports, cultural, and entertainment events, as well as to optimise shopping for a certain period of time.

These research results show that a segment of the Latvian population has not yet understood the severity of the situation and continues to behave as in the summer when the spread of the virus was insignificant. It will be possible to control the pandemic only when the majority of the population follows the principles of social and physical distancing. Currently, the most effective way to reduce the spread of the virus is to practice social distancing and stay at home – to study and to work remotely.

5 CONCLUSIONS

Mobile phone activity during the spring and autumn emergencies still has been high in both cities and country, reaching 70 % to 80 %of the pre-crisis period. Since the spring, the behaviour and habits of the population have changed significantly, so a different approach is needed.

Residents' shopping habits have changed significantly – on weekends, the number of visitors in shopping centres has dropped significantly as people choose to shop on weekdays instead. Human activity at household goods stores has remained high since spring.

People's activity decreases on weekends, while activity on weekdays even increases slightly. At present, introducing the same restrictions as in the spring has failed to achieve an equivalent behavioural change and the level of discipline.

Restrictions on weekends have increased shopping activity on weekdays, where activity was already much higher than on weekends. Authorities ought to examine the possibility of applying restrictions to all days of the week, not just holidays, to compensate for the uneven workload of the shopping infrastructure.

Restrictions that balance the day-to-day shopping load should be considered to limit the number of people who visit the store at the same time, creating peak visits.

It is necessary to create and communicate positive alternatives to spending weekends and holidays in shopping centres, because restrictions alone do not achieve the desired effect and provoke negative reactions.

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