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Effects of COVID-19 on mobility GHG emissions: Case of the city of Lahti, Finland

Elisa Kareinen, Ville Uusitalo, Anna Kuokkanen, Jarkko Levänen, Lassi Linnanen

Lappeenranta-Lahti University of Technology LUT, Mikkulankatu 19, Lahti 15210, Finland

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ABSTRACT

The coronavirus disease COVID-19 has spread worldwide since early 2020, and it has impacted mobility emissions due to mobility restrictions and e.g. increased remote work. This creates a good opportunity to assess how mobility emissions have reduced due to COVID-19. This research is based on data related to mobility distances and modes that have been automatically collected by using a mobile phone application in the city of Lahti, Finland. The results show that mobility decreased in total by approximately 40% during the first wave of COVID-19 in spring 2020. The global warming potential decreased at the same time by approximately 36%. In addition, a considerable shift in modal shares could be seen. The relative modal share of passenger cars increased by 6 percentage points while the share of public transport decreased by 18 percentage points. Despite the considerable reduction, further reductions in emissions from mobility are needed to meet the 1.5 degree climate targets in the urban mobility sector. However, further reductions can be reached also by increasingly using renewable mobility energy sources.

1. Introduction

The coronavirus disease COVID-19 started spreading in late 2019, and a pandemic was declared in March 2020. Over 80 million cases of COVID-19 were confirmed and over 1.5 million people died from the disease during the year 2020 (ECDC, 2021). The first case of COVID-19 in Finland was confirmed in January 2020, and over 36,000 cases were confirmed in 2020 altogether (THL, 2021). The pandemic has had a great operational and financial impact on different sectors worldwide due to e.g. lockdowns in many countries, and it has slowed down the global economy. In addition, COVID-19 has influenced people’s daily lives. For example, many employees started to work remotely and social distancing became the norm. Due to restrictions and fear of COVID-19, a significant change in visits to public places can be seen. In Finland, visits to parks increased by 58% and visits to workplaces decreased by 32% during March-May 2020 (Google 2020).

Global greenhouse gas (GHG) emissions have decreased due to the COVID-19 pandemic. It has been estimated that global daily CO₂ emissions decreased approximately 17% by early April 2020 compared to the 2019 levels (Le Quéré et al. 2020) and approximately 9% in the first half of 2020 compared to 2019 (Liu et al. 2020). COVID-19 has also greatly affected mobility. Mobility rates have decreased evidently: road transport activity dropped by approximately 50% worldwide by the end of March 2020 (IEA, 2020) and by approximately 28% in Finland from mid-March to mid-April 2020 (Finntraffic 2020). The purchase of new private vehicles has collapsed (IEA, 2020), walking and cycling have increased, and mobility related to commuting has decreased greatly as people have been working remotely (Boons et al. 2020). However, the use of public transport has also decreased dramatically – relatively more than the use of private cars and walking in large cities (Gutiérrez et al. 2020). For example, in Canada, cities halted all public transport from mid-March to mid-May (Abu-Rayash & Dincer 2020). The reduction in mobility could reduce GHG emissions after the pandemic if mobility rates do not reach the pre-pandemic levels. However, for example, the SARS pandemic has had only temporary impact on mobility related to tourism (Van Cranenburgh et al. 2012).

The Paris Agreement signed in 2016 aims to hold the global average temperature rise well under 2 degrees Celsius above pre-industrial levels and to pursue efforts to hold it under 1.5 degrees. It has been projected that the average global temperature increase could reach 1.5 °C already by 2026 if business is continued as usual, but more likely after the year 2040 (Connolly et al. 2020). A rise in temperature above 1.5 degrees increases the risk of e.g. extreme weather events. The global average temperature has already risen approximately 1 °C above pre-industrial
levels due to human activity, which has already had an impact on weather events (Hoegh-Guldberg et al. 2018).

The mobility and transport sector is one of the largest emitters of GHG emissions. It covers approximately 23% of global energy-related CO₂ emissions (Sims et al. 2014). GHG emissions from mobility and transport have been increasing annually, and it has been estimated that the emissions will double between 2010 and 2050 if more ambitious policies are not established (OECD 2012). Emissions from mobility and transport in the EU are expected to continue to decline until 2030, but in the current phase it is not enough to achieve the global targets (European Commission 2019). Global yearly CO₂ emissions from mobility and transport are estimated to be over 18 Gt in 2050 if business is continued as usual, whereas if the target of 1.5 °C is to be achieved, the emissions should not exceed 2 Gt (Gota et al. 2018). In 2018, passenger cars caused approximately 44% of the GHG emissions from the mobility and transport sector (IEA, 2019). In addition, passenger transport is estimated to increase by 42% by 2050 in Europe (European Commission 2019). Therefore, to stay within the limits of the Paris Agreement targets, radical GHG emission reductions are needed also in the mobility sector.

Annual GHG emissions from passenger mobility was estimated to be approximately 2.790 kgCO₂eq per capita in Finland, which is approximately 27% of the total carbon footprint of a Finn (Institute of for Global Environmental Strategies, 2019). As passenger mobility covers over one fourth of the total footprint of a Finn, the reduction of emissions in this sector is vital to achieve the climate targets. In addition, domestic total passenger-kilometres have increased by 24% and passenger-kilometres by passenger cars by 29% from 1990 to 2015 in Finland. Passenger-kilometres by public transport have increased only by 3% during the same time period (Ministry of the Environment & Statistics Finland, 2017). In addition, it has been estimated that the number of passenger cars will increase approximately 7% by 2030 and 16% by 2050 (Technical Research Centre of Finland, 2020). As the number of passenger cars increases, GHG emissions are also likely to increase considering that the use of passenger cars continues to increase. Hence, policies to support mobility reductions and the modal shift to more sustainable mobility modes in addition to renewable mobility energy are needed in achieving emission reductions.

The purpose of this article is to analyse impacts of the first wave of COVID-19 in spring 2020 and related restrictions to the urban mobility sector and its emissions. This paper discusses the relation of GHG emission reductions to future climate targets and the role of remote work in emission reductions. In this paper, urban mobility refers to city and rural mobility within Finland, including passenger cars, buses, trains, trams, metros, cycling, and walking. The research focuses on the Finnish operational environment and especially on data from the city of Lahti. Lahti is a city in the Southern Finland with 120 000 residents. Public transport within Lahti is mainly based on local buses, and train connections link Lahti to other cities.

2. Materials and methods

This paper analyses mobility data from two main sources: mobility phone data and national mobility statistics. The data sets collected by mobile phone applications are presented in more detail in Section 2.1. The second data source is statistical data from a Finnish national mobility study which is presented in Section 2.2. The global warming potential (GWP) based on GHG emissions of mobility modes are collected and utilized to analyse related changes. Section 2.3 presents GWP factors for different mobility modes. Finally, Section 2.4 discusses the first wave of COVID-19 in Finland during spring 2020. Table 1 summarizes data used in different parts of our study.

### Table 1

| Data collection and different data sources | Mobility distances and modal shares | Mobility mode specific GWPs |
|------------------------------------------|------------------------------------|-----------------------------|
| Average mobility GWPs before the first wave of COVID-19 | Data I, Data II, Statistical mobility data for Finland | Literature |
| Average mobility GWPs during the first wave of COVID-19 | Data II | Literature |

**2.1. Mobility data gathered in the city of Lahti using mobile phone applications**

Mobility data was collected automatically by using mobile phone applications for the Android and iOS operating systems. The collected mobility data consist of mobility distances and mobility modes. The mobility modes were recognized automatically by using the phone’s accelerometers and additional algorithms, but users had a possibility to correct misrecognitions in their applications. The technology used has been developed by the company Moprim. Mobility distance data was gathered with the same applications using the Global Positioning System (GPS). The mobility modes that the application was able to recognize were passenger car, bus, train, tram, metro, cycling, and walking. Only trips within Finland were recognized, and mobility abroad was not included (Kuokkanen et al. 2020). In addition, aviation is not within the scope of this study. The collection of mobility data only required users to carry a mobile phone with them. Data was collected from 5 October 2018 to 5 April 2019 and from 17 February to 20 September 2020. The first period of data collection is referred to as Data I and the latter as Data II. Fig. 1 presents the mobility phone data collection including the collection periods.

Data I and Data A were gathered using mobile phone application I. Data B was collected using mobile phone application II. The collection technology was the same in both applications and was provided by the same company. Data A and B are combined as one data set, Data II, for further analysis. The data collection was done primarily in the city of Lahti, but users’ mobility in other parts of Finland was also recorded and included in the study. Participants were contacted by advertising the applications in different media, in social media and through mailing lists.

The user group for Data I included 180 participants altogether, but only 89 participants were included in the study based on the amount of active days (a minimum of 14 days) and due to the possibility to connect mobility data and questionnaire responses (Usitalo et al. 2021). The test group for Data II included 961 participants altogether. The activity of the users differed highly as they could start and quit using the application as they wanted. The range of active users per week was from 116 to 363 and on average 191. In addition, background data was not mandatory and therefore not available for all users. Table 2 presents background information for Data I, A, and B. Gender was not queried in Data I. As can be seen in the table, the data covers different age groups and genders.

### 2.2. Statistical mobility data for Finland

A study by the Finnish Transport Agency (2018) is used to obtain a more comprehensive view on mobility in Finland before COVID-19. The study took place in 2016 and covered ten urban areas or regions. The target group included all Finns at least six years of age living in mainland Finland. The study was conducted through phone interviews and via internet and printed questionnaires. Overall, 31,211 Finns participated in the study. The data includes the average length of mobility per mode for walking, cycling, buses, railways, and passenger cars. Altogether, participants travelled approximately 41 km a day. Fig. 2 shows the modal shares of distances travelled a day.

### 2.3. Global warming potential impacts of mobility modes

To assess GWPs related to changes in mobility due to COVID-19, GWP factors have been defined for different mobility modes. In the...
2. First wave of COVID-19 during spring 2020 in Finland

In our study, the first wave of COVID-19 refers to the time period from 17 March to 31 May 2020. The Government of Finland issued its first concrete restrictions on 12 March 2020 by recommending that public gatherings of more than 500 people should be cancelled. On 16 March, the Government invoked the Emergency Powers Act. Consequently, face-to-face education was interrupted in e.g. schools and universities, excluding preschools and grades 1–3, from 18 March until 13 May 2020. In addition, many public buildings were closed, such as libraries and theatres. They were reopened on 1 June 2020. Indoor dining in restaurants was forbidden from 4 April. Restrictions on movement from and to the region of Uusimaa including Finland’s capital were set from 28 March until 15 April. At the start of June 2020, many restrictions were loosened, and for example, museums, public swimming pools, and restaurants could be reopened. However, many restrictions concerning, for example, public gatherings were still partly in effect. Confirmed cases of COVID-19 started rising again from week 38 onward, and the second wave of COVID-19 began in autumn 2020. The dates of restrictions were gathered from different media. Fig. 3 shows the timeline of restrictions during the first wave of COVID-19. The figure also includes the average number of people in hospital care due to COVID-19 during different weeks in Finland, representing the stages of the first wave of the COVID-19 pandemic. This data is available from 25 March 2020 onward (YLE, 2020).

2.4. First wave of COVID-19 during spring 2020 in Finland

GWP, we have included GHG emissions from entire vehicle life cycles including vehicle manufacturing, fuel or energy production and direct emissions from fuel use. End-of-life such as waste management and recycling of vehicles has not been included in this study. Emission factors have been defined for the Finnish operational environment and especially Lahti if possible. For passenger cars, it has been assumed that there is on average 1.7 people in a car (Technical Research Centre of Finland 2017). Table 3 presents emission factors used in the assessment.

Table 3
Life cycle GWPs for mobility modes in Lahti.

| Mobility mode | Vehicle manufacturing (gCO₂eq pkm⁻¹) | Fuel/energy production (gCO₂eq pkm⁻¹) | Fuel use (gCO₂eq pkm⁻¹) | Total (gCO₂eq pkm⁻¹) |
|---------------|--------------------------------------|--------------------------------------|-------------------------|----------------------|
| Walking       | –                                    | –                                    | –                       | –                    |
| Cycling       | 5.0¹                                | –                                    | –                       | 5.0                  |
| Passenger     | 10.1² ± 3                           | 24.1 ± 5, 8                        | 75.0⁶                  | 109.2               |
|                |                                      |                                      | –                       | –                    |
| Buses         | 8.0³, 4                            | 10.5 ± 5, 8                                              | 64.6⁵                  | 63.2                |
| Trains        | 3.0³, 4                            | 2.6 ± 5, 7                                               | –                      | 5.6                  |
| Trams         | 3.0³, 4                            | 2.6 ± 5, 7                                               | –                      | 5.6                  |
| Metro         | 3.0³, 4                            | 2.0 ± 5, 7                                               | –                      | 5.0                  |
| Railways      | 2.0³, 4, 9                         | 2.6 ± 5, 7, 9                                          | –                      | 5.6                  |

¹ European Cyclist Federation (2011)
² EEA (2018)
³ Chester and Horvath (2009)
⁴ Nordolof et al. 2019
⁵ European Commission (2015)
⁶ Technical Research Centre of Finland (2017)
⁷ Motiva (2018)
⁸ Directive 2018/2001
⁹ Finnish Transport Agency (2012)
period.

Fig. 4 shows that mobility rates follow COVID-19 restrictions and the number hospitalized COVID-19 patients. When the number of COVID-19 patients in hospital care increased, the total mobility decreased significantly e.g. due to restrictions and social distancing. When the number of people in hospital care decreased, many restrictions were loosened by the end of week 22 and mobility rates slowly started to increase. According to Data I, users travelled approximately 40 km per day on average before the pandemic. During the first wave, mobility decreased to 24 km per day on average. So, the total decrease was on average 16 km or 40%. Again, when the pandemic eased during the summer, the total mobility grew again. Modal shares of public transport decreased as the pandemic intensified and the relative share of passenger cars increased. For example, the modal share of car usage increased from 64% to 70%, the use of public transport decreased from 27% to 9%, and walking and cycling increased from 9% to 22% when comparing Data I and Data II. In summer 2020, the total mobility rose again approximately to the same level as before COVID-19. A slight decrease in the total mobility can again be seen during late August as the second wave of COVID-19 slowly started (week 35).

Fig. 5 presents mobility related GWPs and COVID-19 patients in hospital care. Calculated average GWPs based on recorded mobility were approximately 21 kgCO₂eq per person per week for Data I and 26 kgCO₂eq for Data II before the first wave of COVID-19. After the first wave, the GWP was on average again approximately 26 kgCO₂eq per person per week. GWPs from mobility during the first wave were approximately 13 kgCO₂eq per person per week. Mobility related weekly GWPs decreased by approximately 8 kgCO₂eq or 36% compared to GWPs before the first wave (Data I), or by approximately 13 kgCO₂eq or 50% (Data II). This means that the distance of mobility and GHG emissions per day decreased roughly the same share. In addition, the relative share of emissions from car usage rose from 93% to 96%. After the first wave, 95% of the emissions were from car usage. Fig. 6 presents the GWPs from mobility for Data I, Data II before the first wave of COVID-19, the statistical mobility data for Finland, and GWPs from mobility during the first wave.

3.2. International comparison of COVID-19 impacts on mobility

The results show that mobility rates decreased by approximately
40% in Lahti, Finland, during the first wave of COVID-19. Mobility in other countries also decreased significantly during the first wave of COVID-19. For example, mobility rates in Sydney, Australia, Sao Paulo, Brazil, New York, USA, and Paris, France, dropped by 85% from their usual level in April 2020 (Statista 2020). Our study shows that GWPs from urban mobility dropped 36–50% during the first wave of COVID-19 in Lahti compared to earlier GWP levels. Our results indicate a slightly greater drop than the study by Liu et al. (2020), which concluded that CO₂ emissions from ground transport dropped by 16.7% in March, 31.9% in April, and 20.7% in May 2020 in the EU-27 and UK. In another study, Schulte-Fischedick et al. (2021) concluded that CO₂ emissions from surface passenger transport dropped by 50% in April 2020 in the EU-27 and UK.

According to the results, the modal share of public transport decreased the most (from 27% to 9%) during the first wave compared to levels before COVID-19. A decrease in the use of public transport can also be seen in the whole Finland, as visits to transit stations decreased by approximately 51% during the first wave (Google 2020). During the first wave, passenger cars covered 96% of mobility related weekly GWPs, and their modal share increased from 64% to 70% in Lahti. Also larger modal share changes can be seen. For example, in Budapest, Hungary, the modal share of passenger cars increased from 43% to 65% while the modal share of public transport decreased from 43% to 18% in March 2020 (Bucsky, 2020). In Germany, the modal share of walking and cycling increased from 58% to 73% during March 21st to April 19th 2020 (Anke et al. 2021). Although the share is higher, the difference is 15 percentage points when the change in our study is 13 percentage points. Anke et al.’s (2021) study also shows that the use of private car increased from 18% to 21%, and the use of public transport decreased from 23% to 5%. A decrease in the use of public transport can also be seen in van der Drift et al.’s (2021) study. The study shows that during an “intelligent” lockdown in March 2020 in Netherlands, public transport was used 1% of the times in the morning rush hour compared to 9% in week 10. In addition, 86% of the users of public transport decided to stay at home while 27% of those who decided to travel changed to car.

When mobility increases after the pandemic, GWPs may also increase from the level before COVID-19 if the modal share of mobility stays the same as during the COVID-19, particularly if the modal share of passenger cars remains high. Research on modal shares after the pandemic is needed to recognize if the GWP from mobility starts to increase to a higher level than before COVID-19. In Das et al.’s (2021) study, 6% of the participants whose household owned a vehicle would use public transport in commuting post pandemic, while 19% of them used public transport before the pandemic. Respectively, 36% would use a car post pandemic while 29% used a car before the pandemic. Research on SARS show that the impact on mobility has only been temporary relating to tourism (Van Cranenburgh et al. 2012). However, SARS did not cause as large-scale and long-lasting precautions and lockdowns as COVID-19.

![Fig. 5. GWPs from mobility in Data II with the number of people in hospital care due to COVID-19 in Finland at different stages of the pandemic.](image1)

![Fig. 6. GWPs from mobility before and during the first wave of COVID-19 in spring 2020.](image2)
around the world has.

### 3.3. Global warming potential of mobility in relation to climate targets

Different actors have set a variety of reduction targets for GHG emissions from mobility. Many of the targets are based on the desire to meet the Paris Agreement targets. A study by the Institute of for Global Environmental Strategies (2019) estimates what the GWP should be in different sectors from the consumption perspective to reach the 1.5 °C target of the Paris Agreement. The sectors included were nutrition, housing, mobility, consumer goods, and leisure and services. One of the countries reviewed in the study was Finland. For passenger mobility in Finland, it was estimated that the GWP should be reduced by 72–85% for the 2030 target and by 96–98% for the 2050 target.

The minimum and maximum emission reduction targets for 2030 and 2050 are calculated based on the GWPs before the first wave of COVID-19 and the reduction targets estimated by the Institute of for Global Environmental Strategies (2019). Results from Data I are used as GWPs from mobility before the first wave of COVID-19 for the maximum target, and results from Data II and the statistical mobility data for Finland as the GWP before the first wave for the minimum target. It is assumed that the reduction of the GWP should be 85% and 98% in the maximum targets and 72% and 96% in the minimum targets. To achieve the minimum estimated emission reduction targets, GWPs should be reduced approximately to 7 kgCO₂eq per person per week by 2030 and approximately to 1 kgCO₂eq per person per week by 2050. Correspondingly, GWPs should be reduced approximately to 3 kgCO₂eq per person per week and to 0.4 kgCO₂eq per person per week for the maximum emission reduction targets. GWPs should therefore still be reduced by 6–10 kgCO₂eq per person per week by 2030 and 12–12.6 kgCO₂eq per person per week by 2050 from the GWP level during the first wave to achieve the estimated reduction targets. Although GWPs decreased significantly during the first wave of COVID-19, GWPs should still be reduced by 45–76% and 92–97% to meet the future climate targets of 2030 and 2050 to stay within limits of the 1.5 degree increase in temperature above the pre-industrial level. This suggests that stricter policies or support from renewable mobility energy sources are needed. However, this research was a case study in the city of Lahti, Finland. So, more research is needed to gain a broader overview of mobility during COVID-19 globally and in Finland in addition to research on GWP’s relation to climate targets during the pandemic. CO₂ emissions from mobility are distributed unequally between population. For example, in Barcelona, Spain, the top 10% of pollutants are responsible of nearly half of the total CO₂ emissions from mobility (Bel & Rosell 2017). Research on inequality in CO₂ emissions during and after the pandemic and the shift in inequality are needed to understand emissions from mobility better and direct policies more efficiently.

One of the targets set by the government programme in Finland is that GWPs from mobility and transport should decrease at least to half by 2030 compared to the 2005 level (Ministry of the Environment 2020). This includes all mobility in Finland, but concentrating only on urban mobility modes included in this study, GWPs dropped rather close to these targets during the first wave of COVID-19. The comparison was made using GWPs of the statistical mobility data for Finland used in this research, as the total mobility in 2005 was approximately at the same level as in 2016. Passenger-kilometres decreased only from 42 to 41 km per person per day, and the modal share of private car remained the same, being 76% (WSP LT-Konsultti Oy 2006; Finnish Transport Agency 2018). Data I and Data II were collected in the city of Lahti, Finland. Lahti has ambitious targets to be carbon neutral by 2025. The target for GWPs in mobility and transport is 25% by the year 2025, which refers to reduction of the total GWP from mobility and transport in the area per capita. It can be concluded that consumption-based emissions decreased more than was required to achieve the target, but it should be kept in mind that the target set by the city is aerial and not consumption based, and therefore, direct comparison is not possible.

### 3.4. Important role of remote work

COVID-19 increased remote work significantly. People in various workplaces switched to remote work rapidly when restrictions and recommendations were put in place in Finland in the middle of March 2020. In Eurofound’s (2020) study, in July 2020, approximately 30% of employees worked only from home and 15% partly from home (altogether 45%). The respective average shares for remote work in the EU-27 countries were approximately 34% and 14% (altogether 48%). The share has increased significantly, as in 2019, only approximately 6% of employees usually worked from home in the EU-27, and approximately 14% in Finland (Eurostat 2020). Remote work decreases the number of journeys to work and also commuting, which decreased the total mobility. Remote work caused a leap in remote work technologies and remote work practices in workplaces. This could enhance the possibility and willingness to work at least partly remotely also after the pandemic.

Remote work could be an effective way to decrease emissions in mobility also in the future. Many employees commute to work, and therefore, remote work would decrease unnecessary journeys to workplaces. For example, 35% of the workforce commuted outside of their municipality in 2018 in Finland and 23% in the city of Lahti (Statistics Finland 2020). The length of the journey to work has been increasing yearly, which might increase emissions if people start driving their car to work or increase the distances they drive. Hence, remote work could cut the trend of increasing commuting distances. In Finland, the average journey to work in 2015 was 14 km, and the trend has been rising at least since 1980, when the average journey was only 6 km (Statistics Finland 2018). In the EU-27, employees in cities worked from home considerably more frequently than employees in less populated areas (Eurofound 2020). Cities usually have better public transport connections, whereas cars are typically needed for travelling in rural areas. Therefore, remote work might not decrease the GWP as much as if more employees in rural areas could work remotely. In addition, the Institute of for Global Environmental Strategies (2019) state that telework of white-collar workers could reduce the GWP only by approximately 225 kgCO₂eq per person per year. In the same study, it was estimated that the best way to decrease emissions in mobility is to reduce leisure travel by car, which would decrease the GWP by over 1 500 kgCO₂eq per person per year if fully adopted. More research on remote work related GWP impacts is required also from a systems perspective by including other sectors than only mobility.

Mobility after the pandemic has potential for modal change. Remote work has become more common and people have grown accustomed to it. Also, travelling patterns before the pandemic could change if journeys to work decreased. However, it might take some time to increase public transport to the level it was before the pandemic. Boons et al. (2020) have formulated different future scenarios of the world after COVID-19: recovery back to normal, the collapse of society, and transition to a qualitatively new form of society due to accelerated sustainability or digitalization. Hence, the transition to more sustainable mobility behaviour could be possible after the pandemic in addition to increasing remote work due to accelerated digitalization. However, it is also possible that no transition would happen, in which case more radical policies would be needed, for example, stricter taxing e.g. for fuels, personal or other carbon trading, and the prohibition of internal combustion engine cars.

### 3.5. Limitations

Data I from Lahti was gathered through mailing list invitations and social media. This means that people not present in these communication channels are not represented in the data. In addition, the data collection could have interested more people who travel in a more environmentally friendly manner and have a lower GWP from mobility. This could also have impacted Data II, although the application for the majority of data collected was marketed for a longer time and in more
places than the application used for Data I. For example, GWPs from Data I were lower than in the statistical mobility data for Finland although the distance was approximately the same. This could also be because Lahti is a fairly large city in Finland with good public transport connections. In the following studies, also other channels for advertising data collection should be used to gain a more diverse sampling. For example, face-to-face advertisement or post could be used. In addition, other mobility data collection methods should be considered, because the use of mobile phone applications may limit possible users. The mobility data was initially collected for a different kind of study. However, collected data enabled us to assess impacts of COVID-19.

4. Conclusions

This research focused on urban mobility emissions during COVID-19 and its relation to climate targets. The research shows that mobility rates decreased by approximately 40% during the first wave of COVID-19 in the city of Lahti, Finland, but soon after the first wave, mobility returned to the level before COVID-19. During the first wave, a considerable shift in modal shares could be seen. The modal share of car usage increased from 64% to 70% and walking and cycling from 9% to 22%. At the same time, the modal share of public transport decreased from 27% to 9%. The GWP from mobility decreased by 36–50% during the first wave of COVID-19. This study shows that the restrictions during the first wave of COVID-19 were not enough for urban mobility to meet the 1.5 degree climate target. Despite the mobility restrictions and remote work during the first wave of COVID-19, the GWP of mobility did not decrease enough, which indicates that stricter policies, changes in modal shares or support from renewable mobility energy sources are still needed to achieve the targets. Remote work could be a more common practice after the pandemic, which could decrease the GWP from mobility and help to achieve the 1.5 degree targets.

CRedit authorship contribution statement

Elisa Kareinen: formal analysis, Methodology, Writing – original draft. Ville Uuisitalo: Methodology, Project administration, Supervision, Writing – review & editing. Anna Kuokkanen: Funding acquisition, Writing, Review & editing. Jarkko Levänen: Writing – review & editing. Lassi Linnanen: Writing – review & editing.

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.

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