



Article title: The impact of COVID-19 related regulations and restrictions on mobility and potential for sustained climate mitigation across the Netherlands, Sweden and the UK: A data-based commentary.

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COVER LETTER

Professor Dan Osborn
Editor-in-Chief, UCL Open
UCL Open: Environment

Dear Professor Osborn,

My co-authors and I would like to submit our Commentary paper entitled “The impact of COVID-19 related regulations and restrictions on mobility and potential for sustained climate mitigation across the Netherlands, Sweden and the UK: A data-based commentary” for publication in the journal, UCL Open: Environment.

This manuscript corresponds to a Commentary paper as outlined in your list of accepted article types.

We are a multidisciplinary group of researchers including behavioural scientists, health and environmental psychologists, service designers and engineers from institutions across Europe.

This paper outlines behaviour changes made concerning transport across the Netherlands, Sweden and the UK during 2020 in response to restrictions and regulations to mitigate the spread of COVID-19. Additionally, we aim to understand these changes from the perspective of behavioural theory to make policy recommendations towards maintaining pro-environmental behaviour changes, potentially mitigating climate change.

We consider that there is added value in sharing our commentary with the scientific community. To our knowledge, there are no published examples of behaviour change theories applied within this context. Also, our policy and research recommendations apply to understanding and changing an array of pro-environmental behaviours, offering insights into the opportunities available by capitalising on the moment of change represented by the COVID-19 pandemic.

This paper has not been published or accepted for publication anywhere else and complies with APA ethical guidelines. It is not under review at another journal. Please contact me if I can provide any further information. Thank you for your consideration.

Yours Sincerely,

Elizabeth Corker

Senior Research Fellow, Centre for Behaviour Change, UCL
(on behalf of all authors)

Title: The impact of COVID-19 related regulations and restrictions on mobility and potential for sustained climate mitigation across the Netherlands, Sweden and the UK: A data-based commentary.

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ABSTRACT (word count: 202)

Human behaviour change is necessary to meet targets set by the Paris Agreement to mitigate climate change. Restrictions and regulations put in place globally to mitigate the spread of COVID-19 during 2020 have had a substantial impact on everyday life, including many carbon-intensive behaviours such as transportation. Changes to transportation behaviour may reduce carbon emissions. Behaviour change theory can offer perspective on the drivers and influences of behaviour and shape recommendations for how policy-makers can capitalise on any observed behaviour changes that may mitigate climate change. For this commentary, we aimed to describe changes in data relating to transportation behaviours relating to working from home during the COVID-19 pandemic across the Netherlands, Sweden and the UK. We display these identified changes in a concept map, suggesting links between the changes in behaviour and levels of carbon emissions. We consider these changes in relation to a comprehensive and easy to understand model of behaviour, the COM-B, to understand the capabilities, opportunities and behaviours related to the observed behaviour changes and potential policy to mitigate climate change. There is now an opportunity for policy-makers to increase the likelihood of maintaining pro-environmental behaviour changes by providing opportunities, improving capabilities and maintaining motivation for these behaviours.

1. Introduction

Researchers expected that the large-scale behaviour changes required to mitigate the impact of COVID-19 were improbable (Bouman et al., 2020). However, responses to the COVID-19 pandemic have resulted in far-reaching behavioural changes across nations in everyday living, such as mobility and working practices (Beck & Hensher, 2020; Le Quéré et al., 2020). Furthermore, these often thought to be improbable behaviour changes may impact carbon emissions. For example, increased working from home may reduce carbon emissions from commuters, whilst restricting public

transport use may increase private car use and carbon emissions. The pandemic-related restrictions and guidance across Europe presented an opportunity to describe real-time changes in behaviour related to climate change.

To build on the window of opportunity, the UK Foreign, Commonwealth and Development Office convened the European Behaviour Change Network (EBCN), comprising experts in behavioural science, health and environmental psychology, service design and engineering from the Netherlands, Sweden and the UK. The EBCN initiated a project to identify changes in citizens' behaviours during the COVID-19 pandemic that might influence climate mitigation and help stay below a 2°C increase in global warming.

Long-term changes in climate variability resulting from human activity and leading to global warming (National Research Council, 2010) (referred to hereafter as climate change) are one of several wicked problems faced by citizens, governments and policy-makers globally (Rittel & Webber, 1973).

Changes in human behaviour are necessary to achieve climate targets and behavioural sciences can contribute to tackling climate change by understanding current behaviours and identifying ways in which behaviours could change (Intergovernmental Panel on Climate Change, 2014; Nielsen et al., 2020; Steg & Vlek, 2008). Decades of work within the behaviour change field has provided insights into how to develop and deliver behaviour change interventions (Lambe et al., 2020; Michie et al., 2013; Steg et al., 2015; Steg & Vlek, 2008; Stern, 2000; Topal et al., 2021; White et al., 2019). These insights remain under-exploited in government policies to tackle climate change, which often remain largely technology-focused (Whitmarsh, 2020).

Governments are adopting targets to cut carbon emissions; for example, the UK and Sweden aim to produce 'net zero' emissions by 2050 and 2045, respectively, while the Netherlands' target is a 49% reduction in emissions by 2030 and 95% by 2050. From 2020, many citizens across Europe have been advised or instructed to 'work from home' where possible and to limit interactions between people to reduce COVID-19 infection transmission (Cornwall, 2020; West & Michie, 2020). Working from home reduces the use of carbon-intensive transport (De Vos, 2020). Globally, the transport sector is estimated to contribute 14% of annual emissions, including non-CO₂ gases and about a quarter of CO₂ emissions, making transportation a sector with high climate mitigation potential (Intergovernmental Panel on Climate Change, 2014). Nations with highly developed economies produce the most carbon emissions, highlighting global inequalities and disparities (Karthia et al., 2020). Pro-environmental behaviour changes within countries with highly developed economies have the potential to impact climate mitigation (Karthia et al., 2020).

Periods of disruption may offer unique 'moments of change': they can break behavioural patterns and routines due to a change in personal, social, or professional circumstances (Verplanken et al., 2018). Moments of change offer opportunities to intervene and reshape behavioural practices (Verplanken & Wood, 2006). A moment of change may be an opportunity to promote pro-environmental behaviours. The COVID-19 pandemic, viewed as a moment of change, may represent a window of opportunity for policy-makers to initiate pro-environmental behaviour changes amongst citizens. Additionally, policy-makers may provide infrastructure and guidance to increase the likelihood that pro-environmental behaviour changes are maintained long-term.

Here, we describe changes in citizens' transport use behaviours influenced by work-from-home policies during the COVID-19 pandemic. We then consider these changes within a behaviour science framework and identify their potential impact on climate change and policy opportunities for maintaining pro-environmental behaviour change and reversing behaviour change with an environmental cost. Our focus is on the following questions:

- a. What transport use-related behaviour changes have been made by citizens during the 2020 COVID-19 pandemic in the Netherlands, Sweden and the UK?
- b. What is the likely impact of any behaviour changes on climate change?
- c. How can pro-environmental changes be sustained long-term, and how can changes with an environmental cost be reversed?

We address these questions using data from 28 sources: 12 from The Netherlands, nine from Sweden, and seven from the UK. Sources reflected data collected from before COVID-19 restrictions were in place to December 2020. Data included traffic counts, mobile GPS data, sales data and self-report survey data from freely available government and commercial sources. We used multiple sources to triangulate data. We present the following as an illustration of transport-related behaviour changes across the Netherlands, Sweden and the UK. For a description of the methods, see Appendix 1, and for a list of the data sources used for each country, see Appendix 2. We do not compare data between countries due to differences in COVID-19 related measures, cultures and policy agendas, along with varied data sources used in this research.

2. Changes in transport use made by citizens during the COVID-19 pandemic

During the COVID-19 pandemic in 2020, varying restrictions, policies and recommendations relating to behaviour have been in place. For an overview and timeline of the decisions made in the Netherlands, Sweden and the UK, see Appendix 3.

In April 2020, COVID-19 associated restrictions were predicted to decrease public transport use and car traffic related to daily activities such as commuting to work, socialising and shopping, along with a global reduction of carbon emissions (De Vos, 2020; Forster et al., 2020). By the end of March 2020, global road transport activity was almost 50% below the 2019 average (International Energy Agency, 2020). Travel restrictions may reduce well-being (De Vos et al., 2013; Ettema et al., 2010), however, they also provide physical and psychological opportunities to adopt transportation behaviours with less environmental impact (Abu-Rayash & Dincer, 2020). Similarly, changes made to working from home could also lead to a decrease in the consumption of fossil energy through decreasing transportation demand (Kanda & Kivimaa, 2020). Here, we bring together insights from diverse data sources to examine changes in behaviour across three European countries that reflect highly developed economies with different transport demand profiles and divergent policy responses to COVID-19.

2.1 Netherlands data

The number of Dutch citizens working from home almost doubled between March 2020 and December 2020, with some citizens intending to work from home more often after COVID-19 related restrictions end (de Hass et al., 2020; Koninklijke RAI Vereniging, 2020e; van Hagen & Ton, 2020; VMS Insight, 2020).

Since March 2020, public transport use has decreased. Dutch citizens have opted for use of private cars, bikes, and walking instead (de Hass et al., 2020; Kamphuis, 2020; Taale et al., 2020b, 2020a; Translink, 2020), and an increased use of car-sharing services since May 2020 has been reported (ANP, 2020). Dutch citizens biked and walked more after March 2020 than before March 2020, and some citizens report intentions to continue biking instead of taking public transport once COVID-19 restrictions end (de Hass et al., 2020; Taale et al., 2020b).

While many citizens worked from home and the absolute number of commuters was low, commuters travelling by public transport have avoided rush hours (Bakker et al., 2020; de Hass et al.,

2020; Statistics Netherlands, 2020). Again, train travellers reported intentions to avoid rush hours after COVID-19 related restrictions end (van Hagen & Ton, 2020)

The sales of Electric Vehicles (Plug-In Hybrid Vehicles and Fully Electric Vehicles) increased in 2020 compared to 2019, with sales of Electric Bikes (speed pedelecs) and mopeds (electric and manual) doubling during summer 2020 compared to summer 2019 (Koninklijke RAI Vereniging, 2019a, 2019b, 2019c, 2019d, 2020a, 2020b, 2020c, 2020d). While internal combustion engine car sales decreased, more Dutch citizens reported the intention to purchase a car (type not specified) than pre-pandemic levels. Some Dutch citizens expect to use their car more often after COVID-19 restrictions end (AutoScout24, 2020; de Hass et al., 2020; Royal RAI Association, 2020; van Hagen & Ton, 2020).

2.2. Swedish data

Between February and April 2020, the proportion of people working remotely full-time increased from 2% to 32% (Tele2 & Sverige, 2020). Additionally, about 90% of survey respondents reported a desire to continue working from home, at least one day per week, when they have the option to return to offices (Tele2 & Sverige, 2020; The Swedish Confederation of Professional Employees, 2020).

Overall, a significant decline in mobility was observed during the pandemic, suggesting that Swedes followed the Public Health Agency's recommendations and worked from home to a great extent. Data from mobile phone densities show that people stayed more in residential areas during the day (Dahlberg et al., 2020). Additionally, the distance citizens moved from their homes during a day decreased by 38% between January and March 2020 (Dahlberg et al., 2020). Moreover, monitoring of urban noise patterns in central Stockholm showed a significant reduction in noise levels after the recommendation of working from home, confirming the mobility decline (Rumpler et al., 2020).

A 10-30% decrease in car traffic during weekdays and a 30-40% decrease on weekends between March and May 2020 was observed (Trafik Stockholm, 2020). Furthermore, reports show a significant reduction in particulates measured on busy streets in Stockholm (SLB Analys, 2020). As car traffic decreased, so did car sales. The Swedish industry organisation for manufacturers and importers of cars recorded a decrease in private car sales of 18% in 2020 compared to 2019. Of car sales made, Electric Vehicles accounted for 32.2% compared to 11.3% in 2019 (Bil Sweden, 2021).

In terms of active transport, municipal data showed a decrease in pedestrian flows in the inner city of Stockholm; and a slightly lower decrease in the outer city (Stockholm City, 2020). Concerning biking, the municipality recorded a modest decrease in bike use in Stockholm on weekdays and an increase (30-100 % between mid-March to June 2020) on weekends, suggesting citizens were using bikes during leisure time (Stockholm City, 2020). A survey conducted in April 2020 found that 28.6% of respondents reported walking and biking more since the pandemic started, mainly to avoid public transport (Åkerberg & Mackovic, 2020). Data from ticket validations, sales and passenger counts between February and June 2020 shows a decrease of 40-60% in public transport use across the three most populated regions in Sweden compared to the same time in 2019.

2.3. UK data

The proportion of people working from home increased in the UK from 11.4% before the pandemic to 36.2% during the first lockdown, decreasing slightly to 30.7% in November 2020 (The Centre for Climate Change and Social Transformations, 2020). Additionally, 30.6% of people reported a desire to continue working from home after the restrictions related to COVID-19 are lifted (The Centre for Climate Change and Social Transformations, 2020).

Overall, there was a decrease in road traffic: 50-70% during the first national lockdown (March-May 2020) and 30-40% in October 2020, compared to pre-pandemic levels (Department for Transport, 2020). Levels of NO₂ over London decreased by around 31% (Fuller, 2020). New car registrations declined by 29.4% compared to 2019 (The Society of Motor Manufacturers & Traders, 2021).

The use of public transport declined in the UK. Data indicated train use was down by 95% in the first lockdown compared to the same period in 2019 and 75% during the second national lockdown (Department for Transport, 2020). Ticketer, a system for tracking bus use, recorded an 80-85% decrease from March to June 2020 and a 55-65% decrease from November 2020 compared to January 2020 (Department for Transport, 2020). These data are consistent with data recording the number of check-ins at public Wi-Fi hotspot, which indicated a reduction of around 70% in public transport use weekly during the month of October 2020 (Purple, 2020).

Data from Transport for London showed tube journeys decreased by 94% or 100 million during April and May 2020, and by 64% or 60 million in mid-August to mid-October, compared to the same periods in 2019 (Transport for London, 2020). Bus use in London was down by 80% or 140 million journeys in April-May 2020, and 42% or 70 million journeys in October 2020 (Transport for London, 2020). These data are consistent with data from Citymapper showing a reduction of transport use in London by 80-90% in April and May 2020 and 40-50% in November 2020 (Citymapper, 2020).

Cycling trips increased by 100-200% during April-June 2020 and by 50-80% in July-October 2020 compared to March 2020, as reported by data from network provider O2 (Department for Transport, 2020). London specific data from the Santander Cycle Hire Scheme indicated a mixed impact with a decrease in bike hires by 34% in April 2020, an increase by 15% in May 2020, and an increase by 18% in September 2020 when compared to the same periods in 2019 (Transport for London, 2020).

Sales of Electric Vehicles (Fuel Cell Electric Vehicles and Plug-in Hybrid Electric Vehicles) increased by 185.9% and 91.2% respectively (The Society of Motor Manufacturers & Traders, 2021).

3. The likely impact of these transport and mobility behaviour changes on climate change

According to the International Energy Agency (IEA), there is the potential for 35% of the workforce in Europe to work from home long-term (International Energy Agency, 2020). Other sources estimate a potential of 24-31% of home-based work in Europe (International Labour Organization, 2020). The IEA estimates that the pre-COVID proportion of the workforce working from home in Europe was 5% (International Energy Agency, 2020). The climate impact of working from home depends on several variables such as nature of the job, country, residential energy use, commute length and mode of transport. The IEA estimates that if everybody who was able to work from home worldwide did so for one day per week, it could bring an annual decline of 24 million tonnes CO₂ emissions (MtCO₂) and would save 1% of global oil consumption for road passenger transport per year (International Energy Agency, 2020). During the pandemic, it was estimated that 59% of the global workforce were working from home (International Energy Agency, 2020). The reduction of surface transport accounted for just under half of the decrease in CO₂ emissions in April 2020 compared to 2019 levels (Le Quéré et al., 2020). Decreased levels of journeys made by internal engine combustion vehicles as identified here across three countries can have a meaningful impact on carbon emissions. Fewer car journeys in rush hours imply decreasing traffic congestion leading to improved air quality.

This change is consistent with the transport changes required: “technical and behavioural mitigation measures for all transportation modes combined with new infrastructure and urban redevelopment could significantly reduce the energy demand of the sector” (Intergovernmental Panel on Climate Change, 2014, pg 100). As identified here, a decrease in commutes, increased active transport, and the use of Electric Vehicles accelerated during the COVID-19 pandemic and has the potential for significant climate mitigation effect if maintained in future (Mizdrak et al., 2020).

To represent the impact of COVID-19 working from home guidance and other factors on transport use and carbon emissions, we developed a concept map using the available data, theory knowledge and expertise within the EBCN (see Figure 1). In this map, arrows represent hypothesised directional causation. The '+' or '-' symbols represent the direction of change between the two variables linked by an arrow. For example, the '-' signalled at the relationship between 'working from home' and 'use of private transport' shows that increases in working from home lead to an overall decrease in private transport use. This map represents an intervention and related actors (COVID-19 restrictions and policy-makers), the content of the system (working from home, use of private, active and public transport) and the impact of the intervention through the content on the variable (carbon emissions). This map shows the link between COVID-19 restrictions and increased working from home, leading to reduced use of private and public transport and increasing active transport, overall resulting in decreased carbon emissions. It indicates how removing the COVID-19 restrictions might impact carbon emissions.

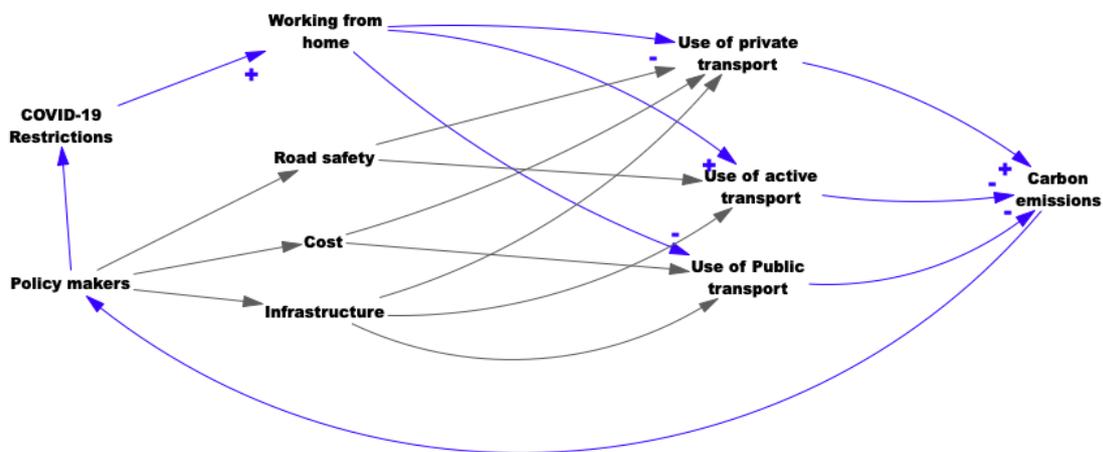


Figure 1. Working from home concept map. Arrows represent causal relationships, with blue arrows representing relationships illustrated by data. (Grey arrows represent variables and links that are known to be important but for which no data was sought for this commentary).

4. Insights from behavioural science relating to COVID-19 related behaviour change and potential impact on climate change

The Capability-Opportunity-Motivation Behaviour model (COM-B) (Michie et al., 2011) represents behaviour as an interacting system. Capability (physical and psychological skills required for a behaviour), opportunity (physical and social context needed for a behaviour), and motivation (brain processes required to direct and influence a behaviour) interact within this system to generate behaviour (see Figure 2).

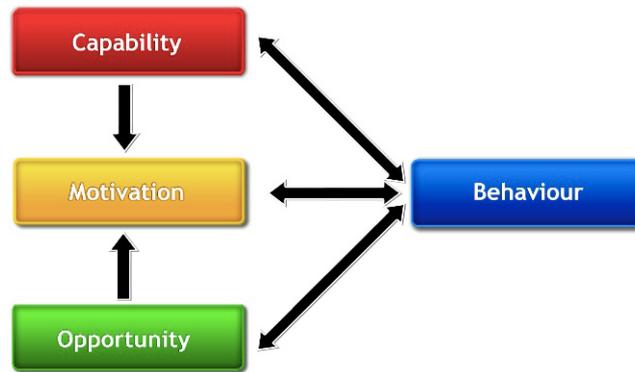


Figure 2. The COM-B model of behaviour (Michie et al, 2011).

The COM-B model links to a framework of interventions and policies, the Behaviour Change Wheel, which in turn links to a taxonomy of 93 specific behaviour change techniques (Michie et al., 2011, 2013). These tools can be used to inform the development and evaluation of interventions and policies concerning behaviour change, including increasing health and sustainability following COVID-19 restrictions (Michie et al., 2020) and reviewing pro-environmental behaviour change interventions (Addo et al., 2018; Hedin et al., 2019; Staddon et al., 2016). Behaviour change theory can be used to hypothesise influences on identified behaviour changes that occurred during periods of COVID-19 related restrictions and guidance and to suggest ways to maintain behaviour changes likely to promote climate mitigation (Bouman et al., 2020).

We cannot predict with certainty how citizens will behave once government recommendations and restrictions end. However, based on COM-B we can predict that the behaviour changes most likely to be maintained are those where there are ongoing opportunities, capabilities and motivation to continue. The pandemic has led to changes in physical *opportunity* (e.g. lockdown policies and technologies enabling home working), improved *capabilities* to engage with digital home working options and increased *motivation* for working at home once restrictions end. Maintaining this pro-environmental behaviour change requires: ensuring that *opportunities* are sustained perhaps through policies relating to flexible working, *capabilities* are continually reviewed and improved to allow employees to connect with colleagues and maintain outputs, and strengthened *motivation*, for example through interventions to improve employees well-being.

The transport-related changes in behaviour we identified are strongly influenced by *opportunity*, with guidance and restrictions mainly advising against using public transport and avoiding travelling altogether, along with working from home recommendations and policies. Consequently, use of public transport decreased. There is evidence that *motivation* decreased for using public transport and increased for private transport use, due to understandings concerning how COVID-19 is transmitted and beliefs that public transport carries a high risk of COVID-19 infection (Lewis, 2020; World Health Organization, 2020). *Opportunity* to use public transport could be increased by improved accessibility and infrastructure that allows for adequate spacing between passengers and other risk-reducing measures. Increasing *opportunity* may increase *motivation* by affirming beliefs that public transport is relatively safe, as would required behaviours of wearing face coverings and sanitising hands before and after transport use.

The identified shift in behaviour towards more pro-environmental active transport during the pandemic was also influenced by *opportunity*. Government restrictions on travel and local authority measures to implement active travel measures (e.g., 'pop up' cycle lanes, pedestrianisation, cycle hire schemes) to enable socially distant movement in towns and cities provided opportunities for active transport. It is reasonable to assume that, in terms of COVID-19 transmission, active transport

is believed to be low-risk. Levels of enjoyment of the experience of walking and cycling may also maintain or increase motivation.

The increase in levels of active transport behaviour is likely to have increased levels of physical *capability* relating to strength and stamina, along with psychological *capabilities* relating to cycling and navigation knowledge and skills. These changes present opportunities for policy relating to work and leisure to maintain capabilities while increasing opportunities for active transport through improving cycling and walking infrastructure. Introducing and maintaining *opportunity* for active transport within a working day would sustain or increase *capabilities* built on during the pandemic, along with potentially increasing pro-environmental related *motivations* to maintain this identified behavioural change. *Opportunities* to purchase Electric Vehicles (including electric-bikes and electric-scooters) could be increased through financial incentives, hire schemes, and the installation of charging points in areas not well connected by public transport (Kothari & Sclar, 2020). Linking the purchase of Electric Vehicles to health and pro-environmental beliefs may also increase *motivation*.

The identified data suggest that overall private transport use decreased during COVID-19 restrictions (Department for Transport, 2020; SLB Analys, 2020; Taale et al., 2020b; Trafik Stockholm, 2020). However, self-report data indicates that intentions to make individual journeys using private transport increased during COVID-19 restrictions (Koninklijke RAI Vereniging, 2020e). There is a risk that, if *capability*, *opportunity* and *motivations* for public and active transport decreases, this could lead to increases in private transport use when fewer restrictions are in place, with the impact being increased carbon emissions. Although changes in policies designed to maintain and increase public and active transport use may have a spill-over effect in decreasing private transport use, it will be necessary to implement specific discouraging actions, for example with the use of low-traffic neighbourhoods, to reduce *opportunity* for private transport use, which may result in a decrease in *motivation* for using private transport.

From a behavioural perspective, to maintain behaviour changes influenced by this moment of change requires ensuring that *opportunities* are sustained or expanded, *capabilities* are continually reviewed and improved, and *motivation* strengthened. Additionally, reversing changes related to environmental cost requires removing *opportunities* or decreasing *motivation* for carbon-intensive behaviours.

5. Policy Implications

To increase the likelihood of long-term behavioural changes to reduce climate change, building on behavioural changes identified during the disruption of the pandemic through policy is necessary. Government action and recovery-package incentives could have a significant long-term effect on global greenhouse gas levels (Le Quéré et al., 2020), with the potential to avoid 0.3°C of global warming by 2050 (Forster et al., 2020). During the COVID-19 pandemic, we have observed that frequent emphasis on the desired behaviour of citizens by governments increases the likelihood of behaviour change (Hyland-Wood et al., 2021). We can link our behavioural analysis using the COM-B model to potential interventions and policies identified in the integrative framework, the Behaviour Change Wheel (Michie et al., 2011). Persuasive and informative communication strategies, as well as environmental and social planning, will be key types of intervention and policy. As nations with more highly developed economies are known to produce the most carbon emissions (Karthan et al., 2020), these nations are the ones that should take the most actions to mitigate carbon emission related impact.

5.1 Working from home

Employees working from home reduce their transport-related behaviours. Many firms now offer workplace flexibility (for example Microsoft, Facebook and Salesforce), allowing employees the opportunity to choose in what form, and if at all, they return to working from the company's offices (Statt, 2021). Changing metrics of productivity, for example, by measuring outcomes instead of inputs, suggests that virtual workers deliver a high quality of work (Alexander et al., 2020). Policies that focus on remote or flexible work locations may benefit both employers and employees who wish to work in this way; communication strategies could draw attention to the benefits of working from home, or in local 'hubs', both for the employees and for the employers. Companies are likely to improve digitally mediated meeting and networking opportunities, and Governments need to ensure good digital access for all. Monitoring the impact of working from home on employee well-being, along with improving and increasing opportunities for colleagues to interact socially are important considerations for employers.

5.2. Public transport

Increasing opportunities to use public transport through improved infrastructure will benefit citizens living within and outside of cities. Improved infrastructure includes having sufficient volume, routes, timetables, bus sizes, ventilation, bus stops, traffic management, and acceptable pricing. Improving communications regarding health and safety measures taken across public transport networks is likely to increase motivation to use public transport by affirming beliefs that public transport is relatively safe. Encouraging a gradual reintroduction of public transport use may help re-establish confidence, and good communications may be persuasive in terms of the environmental benefits of using public transport.

5.3. Private transport

Intentions to use private vehicles more, after restrictions end, were identified, and sales of Electric Vehicles increased in all three countries. Policy-makers could consider ways to support the use of private Electric Vehicles (including electric-bikes and electric-scooters) over conventional vehicles, to maintain motivation and increase opportunity. For instance, various stimulus packages launched across Europe to support purchasing an Electric Vehicle (Wappelhorst, 2020). Investment and expansion of public charging outlets, along with accessible and transparent pricing models, is also required as this is an opportunity-related barrier to purchasing Electric Vehicles (Kothari & Sclar, 2020). Further, policy-makers could consider how Electric Vehicles could be integrated into the public transport system by focusing on urban infrastructure, ensuring dedicated spaces and increasing opportunities and motivation to use these vehicles. Local policies relating to Electric Vehicles have emerged in several cities globally (Connolly, 2020). Increased use of Electric Vehicles could improve air quality and subsequently lower health risk as they have no tailpipe emissions and emit less heat (Ager-Wick Ellingsen et al., 2016). The health and pro-environment related factors may increase reflective motivation to continuing Electric Vehicles use on an individual level.

5.4. Active transport

Providing opportunities to increase or maintain bike use levels may be achieved by making pop-up bike lanes permanent, working with bike-sharing services to offer free 'taster' rides, and increasing the number of bikes and electronic-bikes available. Increasing the availability and accessibility of spaces for active transport modes such as walking and cycling could have long-lasting health benefits by reducing the risks of cardiovascular disease, type-2 diabetes and mental distress (Le Gouais et al., 2021). Government and public health-related communication strategies could highlight and inform citizens about potential personal benefits and frame active modes of transportation as healthy and good for the environment to motivate more citizens to adopt and maintain pro-environmental travel behaviours. The concept of local living or the 15/20-minute city concept, whereby people have access to education, shopping, employment and community facilities

within 15/20 minutes of their home, is one option for achieving and maintaining high levels of active transport (Capasso Da Silva et al., 2020). Local living promotes sustainability and liveability, along with improving the well-being, social and economic aspects of the lives of citizens. Local living allows citizens the opportunity to shift from a car-dependent urban structure to relying mainly on walking and cycling, significantly reducing carbon emissions (Moreno et al., 2021). Moving from concept to practice, the Netherlands and some parts of London have introduced low-traffic neighbourhoods where private motor vehicles can only access businesses and homes and cannot cross through neighbourhoods (Sustrans, 2020). Evaluations of low-traffic neighbourhoods suggest links to increases in active travel through higher likelihoods of cycling (Aldred & Goodman, 2020).

6. Future Work

This commentary describes the impact of COVID-19 related regulations and restrictions on mobility and the potential for sustained climate mitigation across the Netherlands, Sweden and the UK. Further evidence, through surveys and interview-based studies conducted across countries, is needed to confirm trends identified in this commentary and extend analyses beyond work-related land-based travel to include aviation and shipping. Producing a standardised set of data would enable comparisons, highlighting similarities and differences between countries, and drawing potential links to cultural differences, trust in institutions and adherence to policy. Policy changes will have a differing impact on various sections of society. The behaviour changes identified within this report only relate to citizens who are employed. To ensure policies do not create or exacerbate existing social and economic inequality, analysis of socio-economic differences within and between nations are needed to identify those likely to benefit and those who may lose out due to long-term changes induced by the impacts of the COVID-19 pandemic. Economic modelling and scenarios could evaluate the mitigation potential of behavioural trends under different conditions, for example, a long-lasting global recession versus a rapid recovery or more ambitious climate commitments taken by governments. The long-term implications on changing behaviours due to the COVID-19 pandemic are unknown. Actions citizens are currently taking to mitigate the spread of COVID-19 could be built on to promote more climate action, including lobbying for Governmental changes (Bouman et al., 2020).

7. Conclusion

COVID-19 represents a moment of change, during which citizens may be open to new information regarding pro-environmental behaviour changes. Opportunities relating to working from home introduced by COVID-19 related restrictions and regulations, improvements in capabilities to maintain work-related efficacy, and increases in motivation to work from home once restrictions and regulations end could lead to a decrease in carbon emissions through a reduction of commuter road traffic. To maximise the likelihood of maintaining potentially pro-environmental behaviour changes observed in 2020, policy changes, informed by behaviour science, are required.

References

- Abu-Rayash, A., & Dincer, I. (2020). Analysis of mobility trends during the COVID-19 coronavirus pandemic: Exploring the impacts on global aviation and travel in selected cities. *Energy Research and Social Science*, 68. <https://doi.org/10.1016/j.erss.2020.101693>
- Addo, I. B., Thoms, M. C., & Parsons, M. (2018). Household Water Use and Conservation Behavior: A Meta-Analysis. *Water Resources Research*, 54(10), 8381–8400. <https://doi.org/10.1029/2018WR023306>
- Ager-Wick Ellingsen, L., Singh, B., & Hammer Strømman, H. (2016). The size and range effect: Life-cycle greenhouse gas emissions of electric vehicles. *Environmental Research Letters*, 11. <https://doi.org/10.1088/1748-9326/11/5/054010>
- Åkerberg, J. J., & Mackovic, M. (2020). *Can the Corona crisis promote a more sustainable lifestyle?* Jönköping University.
- Aldred, R., & Goodman, A. (2020). *Low Traffic Neighbourhoods, Car Use, and Active Travel: evidence from the People and Places survey of Outer London active travel interventions.* <https://doi.org/https://doi.org/10.31235/osf.io/ejb89>
- Alexander, A., De Smet, A., & Mysore, M. (2020). *Reimagining the postpandemic workforce.* McKinsey Quarterly. <https://www.mckinsey.com/business-functions/organization/our-insights/reimagining-the-postpandemic-workforce>
- ANP. (2020). *Shared car and e-bike more popular in Corona time: the Dutch are trying out alternatives to public transport.* Business Insider. <https://www.businessinsider.nl/coronavirus-ov-mijden-deelauto-gebruik/>
- AutoScout24. (2020). *Intent to buy a car increased again.* <https://www.autoscout24.nl/bedrijf/persoverzicht/persberichten/intentie-om-auto-te-kopen-wederom-gestegen/>
- Bakker, P., Hamersma, M., & Huibregtse, O. (2020). *Public transport and the corona crisis.* https://www.kimnet.nl/binaries/kimnet/documenten/rapporten/2020/07/09/openbaar-vervoer-en-de-coronacrisis/Openbaar+vervoer+en+de+coronacrisis_PDFa.pdf
- Beck, M. J., & Hensher, D. A. (2020). What might the changing incidence of Working from Home (WFH) tell us about future transport and land use agendas. *Transport Reviews*. <https://doi.org/10.1080/01441647.2020.1848141>
- Bil Sweden. (2021). *Definitive new registrations in 2020.* https://www.bilsweden.se/statistik/Nyregistreringar_per_manad_1/nyregistreringar-2020/definitiva-nyregistreringar-under-2020
- Bouman, T., Steg, L., & Dietz, T. (2020). Insights from early COVID-19 responses about promoting sustainable action. *Nature Sustainability*. <https://doi.org/10.1038/s41893-020-00626-x>
- Capasso Da Silva, D., King, D. A., & Lemar, S. (2020). Accessibility in practice: 20-minute city as a sustainability planning goal. *Sustainability (Switzerland)*, 12. <https://doi.org/10.3390/SU12010129>
- Citymapper. (2020). *Citymapper Mobility Index London.* <https://citymapper.com/cmi/london>
- Connolly, K. (2020). *“Cleaner and greener”: Covid-19 prompts world’s cities to free public space of cars.* The Guardian. <https://www.theguardian.com/world/2020/may/18/cleaner-and-greener-covid-19-prompts-worlds-cities-to-free-public-space-of-cars>
- Cornwall, W. (2020). *Crushing coronavirus means ‘breaking the habits of a lifetime’.* *Behavior scientists have some tips.* Science. <https://www.sciencemag.org/news/2020/04/crushing-coronavirus-means-breaking-habits-lifetime-behavior-scientists-have-some-tips>
- Dahlberg, M., Edin, P. A., Grönqvist, E., Lyhagen, J., Östh, J., Siretskiy, A., & Toger, M. (2020). Effects of the COVID-19 pandemic on population mobility under mild policies: Causal evidence from Sweden. *ArXiv*.
- de Hass, M., Faber, R., & Hamersma, M. (2020). *New insights on mobility and the corona crisis.* <https://www.kimnet.nl/publicaties/brochures/2020/07/21/nieuwe-inzichten-mobiliteit-en-de>

coronacrisis

- De Vos, J. (2020). The effect of COVID-19 and subsequent social distancing on travel behavior. *Transportation Research Interdisciplinary Perspectives*, 5, 100121. <https://doi.org/10.1016/j.trip.2020.100121>
- De Vos, J., Schwanen, T., van Acker, V., & Witlox, F. (2013). Travel and Subjective Well-Being: A Focus on Findings, Methods and Future Research Needs. *Transport Reviews*, 33(4), 421–442. <https://doi.org/10.1080/01441647.2013.815665>
- Department for Transport. (2020). *Transport use during the coronavirus (COVID-19) pandemic*. <https://www.gov.uk/government/statistics/transport-use-during-the-coronavirus-covid-19-pandemic>
- Ettema, D., Gärling, T., Olsson, L. E., & Friman, M. (2010). Out-of-home activities, daily travel, and subjective well-being. *Transportation Research Part A: Policy and Practice*, 44(9), 723–732. <https://doi.org/10.1016/j.tra.2010.07.005>
- Forster, P. M., Forster, H. I., Evans, M. J., Gidden, M. J., Jones, C. D., Keller, C. A., Lamboll, R. D., Quéré, C. Le, Rogelj, J., Rosen, D., Schleussner, C. F., Richardson, T. B., Smith, C. J., & Turnock, S. T. (2020). Current and future global climate impacts resulting from COVID-19. *Nature Climate Change*, 10(10), 913–919. <https://doi.org/10.1038/s41558-020-0883-0>
- Fuller, G. (2020). *Covid-19 lockdowns have improved global air quality, data shows*. The Guardian. <https://www.theguardian.com/environment/2020/oct/08/covid-19-lockdowns-global-air-quality-india-london-uk>
- Hedin, B., Katzeff, C., Eriksson, E., & Pargman, D. (2019). A systematic review of digital behaviour change interventions for more sustainable food consumption. *Sustainability*, 11(9), 1–23. <https://doi.org/10.3390/su11092638>
- Hyland-Wood, B., Gardner, J., Leask, J., & Ecker, U. K. H. (2021). Toward effective government communication strategies in the era of COVID-19. *Humanities and Social Sciences Communications*, 8(1), 1–11. <https://doi.org/10.1057/s41599-020-00701-w>
- Intergovernmental Panel on Climate Change. (2014). *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. [https://doi.org/10.1016/S0022-0248\(00\)00575-3](https://doi.org/10.1016/S0022-0248(00)00575-3)
- International Energy Agency. (2020). *Working from home can save energy and reduce emissions. But how much?* <https://www.iea.org/commentaries/working-from-home-can-save-energy-and-reduce-emissions-but-how-much>
- International Labour Organization. (2020). *Working from home: estimating the worldwide potential*. https://www.ilo.org/global/topics/non-standard-employment/publications/WCMS_743447/lang--en/index.htm
- Kamphuis, L. (2020). *Research: traveling during the corona crisis*. https://eenvandaag.assets.avrotros.nl/user_upload/PDF/2020_05_10_openbaar_vervoer.pdf
- Kanda, W., & Kivimaa, P. (2020). What opportunities could the COVID-19 outbreak offer for sustainability transitions research on electricity and mobility? *Energy Research and Social Science*, 68. <https://doi.org/10.1016/j.erss.2020.101666>
- Kartha, S., Kemp-Benedict, E., Ghosh, E., Nazareth, A., & Gore, T. (2020). *The carbon equality era*. <https://cdn.sei.org/wp-content/uploads/2020/09/research-report-carbon-inequality-era.pdf>
- Koninklijke RAI Vereniging. (2019a). *Monthly report alternative fuels for passenger cars and light commercial vehicles*. <https://www.raivereniging.nl/pers/marktinformatie/actuele-verkoopcijfers/verkoopcijfers-2019.html>
- Koninklijke RAI Vereniging. (2019b). *Monthly report mopeds*. <https://www.raivereniging.nl/pers/marktinformatie/actuele-verkoopcijfers/verkoopcijfers-2019.html>
- Koninklijke RAI Vereniging. (2019c). *Monthly report passenger cars*. <https://www.raivereniging.nl/pers/marktinformatie/actuele-verkoopcijfers/verkoopcijfers-2019.html>

- Koninklijke RAI Vereniging. (2019d). *Montly report speed pedelecs*.
<https://www.raivereniging.nl/pers/marktinformatie/actuele-verkoopcijfers/verkoopcijfers-2019.html>
- Koninklijke RAI Vereniging. (2020e). *Towards healthy mobility*.
<https://www.raivereniging.nl/binaries/content/assets/downloads/jaaroverzicht-2020.pdf>
- Kothari, V., & Sclar, R. (2020). *4 Reasons to Prioritize Electric Vehicles After COVID-19*. World Resources Institute. <https://www.wri.org/insights/4-reasons-prioritize-electric-vehicles-after-covid-19>
- Lambe, F., Ran, Y., Jürisoo, M., Holmlid, S., Muhoza, C., Johnson, O., & Osborne, M. (2020). Embracing complexity: A transdisciplinary conceptual framework for understanding behavior change in the context of development-focused interventions. *World Development*, *126*, 104703. <https://doi.org/10.1016/j.worlddev.2019.104703>
- Le Gouais, A., Panter, J. R., Cope, A., Powell, J. E., Bird, E. L., Woodcock, J., Ogilvie, D., & Foley, L. (2021). A natural experimental study of new walking and cycling infrastructure across the United Kingdom: The Connect2 programme. *Journal of Transport and Health*, *20*.
<https://doi.org/10.1016/j.jth.2020.100968>
- Le Quéré, C., Jackson, R. B., Jones, M. W., Smith, A. J. P., Abernethy, S., Andrew, R. M., De-Gol, A. J., Willis, D. R., Shan, Y., Canadell, J. G., Friedlingstein, P., Creutzig, F., & Peters, G. P. (2020). Temporary reduction in daily global CO2 emissions during the COVID-19 forced confinement. *Nature Climate Change*, *10*(7), 647–653. <https://doi.org/10.1038/s41558-020-0797-x>
- Lewis, D. (2020). Is the Coronavirus Airborne? Experts can't Agree. *Nature*, *580*.
- Michie, S., Richardson, M., Johnston, M., Abraham, C., Francis, J., Hardeman, W., Eccles, M., Cane, J., & Wood, C. E. (2013). The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: Building an international consensus for the reporting of behavior change interventions. *Ann Behav Med*, *46*(1), 81–95. <https://doi.org/10.1007/s12160-013-9486-6>
- Michie, S., Stralen, M. M. Van, & West, R. (2011). The behaviour change wheel: A new method for characterising and designing behaviour change interventions. *Implementation Science*, *6*(42).
<https://doi.org/https://doi.org/10.1186/1748-5908-6-42>
- Michie, S., West, R., Rogers, M. B., Bonell, C., Rubin, G. J., & Amlôt, R. (2020). Reducing SARS-CoV-2 transmission in the UK: A behavioural science approach to identifying options for increasing adherence to social distancing and shielding vulnerable people. *British Journal of Health Psychology*, *25*(4), 945–956. <https://doi.org/10.1111/bjhp.12428>
- Mizdrak, A., Cobiac, L. J., Cleghorn, C. L., Woodward, A., & Blakely, T. (2020). Fuelling walking and cycling: human powered locomotion is associated with non-negligible greenhouse gas emissions. *Scientific Reports*, *10*. <https://doi.org/10.1038/s41598-020-66170-y>
- Moreno, C., Allam, Z., Chabaud, D., Gall, C., & Pratlong, F. (2021). Introducing the “15-Minute City”: Sustainability, resilience and place identity in future post-pandemic cities. *Smart Cities*, *4*(1), 93–111. <https://doi.org/10.3390/smartcities4010006>
- National Research Council. (2010). *Advancing the Science of Climate Change*. The National Academies Press.
- Nielsen, K. S., Clayton, S., Stern, P. C., Dietz, T., Capstick, S., & Whitmarsh, L. (2020). How Psychology Can Help Limit Climate Change. *American Psychologist*. <https://doi.org/10.1037/amp0000624>
- Purple. (2020). *Global Footfall Trends*. <https://purple.ai/global-footfall-trends/>
- Rittel, H., & Webber, M. (1973). Dilemmas in a general theory of planning. *Policy Sciences*, *4*(2), 155–169. <https://doi.org/https://doi.org/10.1007/BF01405730>
- Royal RAI Association. (2020). *Corona crisis is permanently changing mobility*.
<https://www.raivereniging.nl/pers/persberichten/2020-q2/0512-coronacrisis-verandert-mobiliteit-blijvend.html>
- Rumpler, R., Venkataraman, S., & Göransson, P. (2020). An observation of the impact of CoViD-19 recommendation measures monitored through urban noise levels in central Stockholm, Sweden. *Sustainable Cities and Society*, *63*. <https://doi.org/10.1016/j.scs.2020.102469>

- SLB Analys. (2020). *The Effect of Coronavirus on Air Quality in Stockholm*.
<http://slb.nu/slbanalys/coronas-effekt-pa-luftkvaliteten/>
- Staddon, S. C., Cyclic, C., Goulden, M., Leygue, C., & Spence, A. (2016). Intervening to change behaviour and save energy in the workplace: A systematic review of available evidence. *Energy Research and Social Science*, 17, 30–51. <https://doi.org/10.1016/j.erss.2016.03.027>
- Statistics Netherlands. (2020). *During the corona crisis up to 90 percent fewer check-ins*.
<https://www.cbs.nl/nl-nl/nieuws/2020/37/tijdens-coronacrisis-tot-90-procent-minder-check-ins-ov>
- Statt, N. (2021). *Salesforce declares the 9-to-5 workday dead, will let some employees work remotely from now on*. The Verge. <https://www.theverge.com/2021/2/9/22275304/salesforce-remote-work-9-to-5-workday-is-dead-flex-coronavirus>
- Steg, L., Perlaviciute, G., & van der Werff, E. (2015). Understanding the human dimensions of a sustainable energy transition. *Frontiers in Psychology*, 6(June), 1–17.
<https://doi.org/10.3389/fpsyg.2015.00805>
- Steg, L., & Vlek, C. (2008). Encouraging pro-environmental behaviour: An integrative review and research agenda. *Journal of Environmental Psychology*, 29(3), 309–317.
<https://doi.org/10.1016/j.jenvp.2008.10.004>
- Stern, P. C. (2000). Toward a coherent theory of environmentally significant behavior. *Journal of Social Issues*, 56(3), 407–424. <https://doi.org/10.1111/0022-4537.00175>
- Stockholm City. (2020). *The environmental barometer*.
<http://miljobarometern.stockholm.se/trafik/covid-19/gangtrafik-per-vecka/>
- Sustrans. (2020). *An introductory guide to low traffic neighbourhood design*.
<https://www.sustrans.org.uk/for-professionals/infrastructure/an-introductory-guide-to-low-traffic-neighbourhood-design/>
- Taale, H., Olde Kalter, M.-J., de Bruin, R., Smit, R., & Barnas, B. (2020a). *Background report "Monitoring mobility and transport."* <https://maaksamenruimte.nl/wp-content/uploads/2020/11/20201118-Achtergrondrapportage-Monitoring-Mobiliteit.pdf>
- Taale, H., Olde Kalter, M.-J., de Bruin, R., Smit, R., & Barnas, B. (2020b). *Background report "Monitoring mobility COVID-19."*
https://www.verkeerskunde.nl/sites/default/files/users/user166/20200930_Achtergrondrapportage_Monitoring_Mobiliteit.pdf
- Tele2, & Sverige, A. B. (2020). *Telework Has Increased By 400% During The Corona Crisis Shows Survey From Tele2*. <https://mb.cision.com/Main/7793/3109060/1246021.pdf>
- The Centre for Climate Change and Social Transformations. (2020). *How has COVID-19 impacted low-carbon lifestyles and attitudes towards climate action?* <https://cast.ac.uk/wp-content/uploads/2020/09/CAST-Briefing-04-Covid-low-carbon-choices.pdf>
- The Society of Motor Manufacturers & Traders. (2021). *UK automotive looks to green recovery strategy after -29.4% fall in new car registrations in 2020*.
<https://www.smm.co.uk/2021/01/uk-automotive-looks-to-green-recovery-strategy-after-29-4-fall-in-new-car-registrations-in-2020/>
- The Swedish Confederation of Professional Employees. (2020). *Many who work at home feel good - but miss their colleagues*. <https://www.tco.se/nyheter-och-debatt/Pressmeddelanden/2020/manga-som-jobbar-hemma-trivs-bra--men-saknar-kollegorna/>
- Topal, H. F., Hunt, D. V. L., & Rogers, C. D. F. (2021). Exploring urban sustainability understanding and behaviour: A systematic review towards a conceptual framework. *Sustainability (Switzerland)*, 13(3), 1–33. <https://doi.org/10.3390/su13031139>
- Trafik Stockholm. (2020). *Collected reports over the traffic flow*.
http://miljobarometern.stockholm.se/content/Trafikrelaterat/Covid-19/Månadsrapport_juni.pdf
- Translink. (2020). *Impact corona virus*.

- <https://app.powerbi.com/view?r=eyJrIjoiMDNmZWQ5ZDYtMmI5OS00ZTgyLWI2NjgtY2I0NDhmNzQ5OWZlhiwidCI6IjVjMTM0ZjEzLWE1MmUtNDZhNi1iOGIwLWNIYzY0NDhiMzczYSIsImMiOj99>
 Transport for London. (2020). *Public Transport Journeys by Type of Transport*.
<https://data.london.gov.uk/download/public-transport-journeys-type-transport/a7a69c22-150c-49f3-a1fd-90d4c24d98d4/tfl-journeys-type.xlsx>
- van Hagen, M., & Ton, D. (2020). *Corona's impact on the behavior of train passengers*.
- Verplanken, B., Roy, D., & Whitmarsh, L. (2018). Cracks in the Wall: Habit Discontinuities as Vehicles for Behavior Change. In B. Verplanken (Ed.), *The Psychology of Habit*. Springer.
- Verplanken, B., & Wood, W. (2006). Interventions to break and create consumer habits. *Journal of Public Policy and Marketing*, 25(1), 90–103. <https://doi.org/10.1509/jppm.25.1.90>
- VMS Insight. (2020). *Influence of corona on business mobility*. https://vms-insight.nl/wp-content/uploads/2020/09/Infographic_NZMO-2020_eerste-meting_12-aug-2020_def.pdf
- Wappelhorst, S. (2020). *Economic recovery packages in response to COVID-19: Another push for electric vehicles in Europe?* The International Council on Clean Transportation.
<https://theicct.org/blog/staff/economic-recovery-covid-19-ev-europe-aug2020>
- West, R., & Michie, S. (2020). Routes of transmission of SARS-CoV-2 and behaviours to block it: a summary. *Qeios*, 5–8. <https://doi.org/10.32388/f6m5cb.2>
- White, K., Habib, R., & Hardisty, D. J. (2019). How to SHIFT consumer behaviors to be more sustainable: A literature review and guiding framework. *Journal of Marketing*, 83(3), 22–49. <https://doi.org/10.1177/0022242919825649>
- Whitmarsh, L. (2020). "Boris Johnson's green industrial revolution." *Letter Received by The Times*. <https://www.thetimes.co.uk/edition/comment/times-letters-boris-johnson-s-green-industrial-revolution-g76s2przl>
- World Health Organization. (2020). *Modes of transmission of virus causing COVID-19: implications for IPC precaution recommendations*. <https://www.who.int/news-room/commentaries/detail/modes-of-transmission-of-virus-causing-covid-19-implications-for-ipc-precaution-recommendations>

Appendix 1 – Methods

Data sources

We searched for freely available data (including but not restricted to: attitudinal surveys, sales data and transport ticketing data) from government, transport and commercial sources in the Netherlands, Sweden and the UK and sought reports and datasets through members of the European Behaviour Change Network (EBCN) and colleagues.

To have an accurate picture of the context in which any changes in behaviour were recorded, we also searched government websites for policy or guidance documents within the Netherlands, Sweden and the UK, requesting or legislating changes that would impact on behaviour, such as the closure of cafes and restaurants.

Differences were observed in the ways that data was collected between countries. We did not conduct quality assessments on the data we used, and no weighting was applied to any particular type or source of data. Datasets did not include identifiable information of individuals.

Criteria for data inclusion

Population

Citizens living in the Netherlands, Sweden or the UK.

Language

English, Dutch or Swedish languages.

Outcomes

(i) validated or industry-standard metrics, for example, total number of cars passing a particular point, during a specific time frame, or (ii) self-reported behaviour.

Comparison

To illustrate differences in behaviour between time points, we included sources that had data from at least one-time point before COVID-19 restrictions began, and from within the timeframes of COVID-19 restrictions.

Data extraction and analysis

Using a data extraction form developed for this study (Supplementary File 1), we extracted data on: country; region (international, national or regional); city (if applicable); population (general adult etc); time frame; main focus of source (car, walking etc.); whether a change in behaviour change was recorded; brief description of behaviour change; likely impact on climate change (positive impact = lower carbon emissions); evidence of opportunity to maintain behaviour change (any reference to policy change etc) and evidence of motivation to maintain behaviour change (any evidence of attitude change etc).

Data from each country was extracted by a single author and its inclusion was reviewed by a subset of the authors.

Data synthesis

A descriptive narrative synthesis of data was conducted for each research question for each country. A similar synthesis was conducted to explore similarities and differences between the countries. Where possible, differences due solely to legislation differences were highlighted. A concept map was developed using the available data, theory knowledge and EBCN expertise to visually represent influences on behaviour. We sought feedback from experts within the EBCN network and used this feedback to inform the final concept map.

Appendix 2 – Data sources from each country

Table 1. Data sources for the Netherlands case

Data source	Outcome assessment	Behaviour change observed during COVID-19 pandemic (up to December 2020)
ANP, 2020	Secondary analysis of data from car-sharing companies	Increase in use of car-sharing
Autoscout24, 2020	Self-report from sample of car users	Increases in intentions to use car
Bakker, P., Hamersma, M., Huibregtse, O., & Jorritsma, P., 2020	Primary analysis of public transport data	Decrease in use of public transport
De Haas, M., Hamersma, M., & Faber, R., 2020	Primary analysis of self-report data	Decrease in overall mobility
Kamphuis, L., 2020	Primary analysis of self-report data	Decrease in intentions to use public transport
Koninklijke Vereniging RAI	Primary analysis of self-report data and sales data	Increase in proportion of people working from home; increase in intentions to use a car; increase in sales of Electric Vehicles
Royal RAI Association	Primary analysis of self-report data	Increased intentions to use private modes of transport when restrictions are lifted
Statistics Netherlands, 2020	Primary analysis of public transport data	Decrease in use of public transport
Taale, Olde Kalter, De Bruin, Smit, & Barnas, 2020	Secondary analysis of self-report data	Decrease in use of public transport; increase in intention to cycle
Translink, 2020	Primary analysis of public transport data	Decrease in use of public transport
Van Hagen, M., & Ton, D., 2020	Primary analysis of self-report data	Increase in intentions to work from home; increased intentions to avoid rush-hour travel; increased intentions to use car
VMS Insight 2020	Primary analysis of self-report data	Increases in proportion of people working from home; increases in intention to avoid rush-hour travel

Table 2. Data sources for the Swedish case

Data source	Outcome assessment	Behaviour change observed during COVID-19 pandemic (up to December 2020)
Åkerberg, Mackovic, and Kall 2020	Primary analysis of self-report data	Increases in walking and cycling
BIL Sweden 2020	Primary analysis of car sales	Increase in the proportion of e-mobility modes sold
Dahlberg et al. 2020	Primary analysis of GPS data from mobile phones	Decreases in overall mobility

Rumpler, Venkataraman, and Göransson 2020	Primary analysis of noise patterns	Decrease in levels of noise
SLB Analys 2020	Primary analysis of air particulates	Decrease in levels of particulates in air
Stockholm City 2020	Primary analysis of active transport flow	Decrease in proportion of people waking, changes in proportion of people cycling
Tele2 Sverige AB 2020	Primary analysis of self-report data	Increase in proportion of people working from home; increase in proportion of people with intention to work from home
The Swedish Confederation of Professional Employees	Primary analysis of self-report data	Increase in proportion of people with intention to work from home
Trafik Stockholm 2020	Primary analysis of traffic count	Decrease in overall traffic levels

Table 3. Data sources for the UK case

Data source	Outcome assessment	Behaviour change observed during COVID-19 pandemic (up to December 2020)
Citymapper, 2020	Primary analysis of data from Citymapper users	Decrease in public transport use
Department for Transport, 2020	Primary analysis of transport data	Decrease in road traffic; decrease in public transport use; Increase in cycle use
Fuller 2020	Secondary analysis of air quality	Decreases in levels of NO ₂ in air in London
Purple, 2020	Primary analysis of Wi-Fi hotspot use	Decrease in public transport use
The Centre for Climate Change and Social Transformation, 2020	Primary analysis of self-report data	Increase in proportion of people working from home; Increase in proportion of people with intention to work from home
The Society of Motor Manufacturers & Traders, 2021	Primary analysis of vehicle sales	Decreases in vehicles sold; increase in e-mobility modes sold
Transport for London, 2020	Primary analysis of transport use in London	Decrease in public transport use; increase in cycle use

Appendix 3 – Restrictions and recommendations in The Netherlands, Sweden and the UK

Political decisions in The Netherlands during COVID-19

The Dutch government used a mixture of restrictions and recommendations, referring to the recommendations as ‘basic rules’. These recommendations included working from home as much as possible, keeping 1.5-meter distance from others, limits on the number of visitors at home and no unnecessary public transport travel. The list in Table 1 was based on sources from the Dutch government (Rijksoverheid, 2020a, 2020b, 2020c, 2020d, 2020e, 2020f, 2020g, 2020h, 2020i, 2020j)

Table 5 *List of recommendations and restrictions in The Netherlands during COVID-19*

In effect (2020)	Recommendation or restriction
12 th Dec	Closure of bars, restaurants and cafes
1 st June-14 th Oct	Bars, restaurants and cafes re-open, 30 guests were allowed to sit inside
24 th March – 11 th May	First national lockdown
15 th March- 31 st June	Gyms and other sport facilities closed
24 th March-11 th May	Hairdressers, nail salons and other ‘contact’ services closed
March, April and May and 4 th -18 th of November	Zoo’s, theatres, cinemas and other public locations closed
March-June	public transport limit number of seats available for passenger use
16 th March-June	Schools closed
March	Stores and markets must take measures to ensure social distancing between customers
March	Public events banned
March	Advised to work from home unless impossible
March	Limits on number of indoor visits to a household

Political decisions in Sweden during COVID-19

The Swedish response to the pandemic in 2020 was unique compared to most other countries in the world, with less restrictive social distancing policies and recommendations rather than more drastic policies such as lockdowns. The response relied heavily on citizens taking responsibility and following the recommendations. In Sweden, The Public Health Agency (Folkhälsomyndigheten) is an expert agency with a role for informing the government and the general public on public health matters, and a responsibility to provide suggestions for public policies. Table 2 summarises recommendations and restrictions announced by the Public Health Agency of Sweden and the Swedish Government (Regeringskansliet) between March and December 2020 (Folkhälsomyndigheten, 2020k, 2020n, 2020j, 2020a, 2020l, 2020m, 2020o, 2020p, 2020q, 2020r, 2020s, 2020t, 2020b, 2020c, 2020d, 2020e, 2020f, 2020g, 2020h, 2020i; Regeringskansliet, 2020b, 2020a).

Table 6. *List of recommendations and restrictions in Sweden during COVID-19*

In effect 2020	Recommendation or restriction
March 12	Ban of public gatherings of more than 500 people

March 13	Recommendation for anyone with symptoms of common cold to stay home
March 16	Recommendation for remote work in Stockholm
March 16	Recommendation for anyone aged over 70 years old to minimize physical interactions
March 17	Recommendation for remote teaching at high schools and universities, followed by a gradual closing of universities and upper secondary schools to students
March 19	Recommendation to avoid unnecessary travel
March 24	Restriction to allow table service only, in bars and restaurants
March 27	Banned public gatherings of more than 50 people
April 1st	Recommendation to keep distance from each other, including recommendations for stores to limit number consumers, sport practice to be hold outdoors, limit number of travellers in public transport and adapt amount of public transport adapt to limit crowding
June 13	The recommendation to avoid unnecessary travels is lifted
June 15	The recommendation on distance education for high schools is lifted
July 1st	New law in effect stipulating restaurants have a responsibility to take measures to prevent the spread of COVID-19
July 30	Recommendation to keep working from home until autumn when possible
October 1	Recommendation to avoid visiting elderly home lifted in some cases
October 19	The FoHM decides to allow local authorities to enforce local recommendations and restrictions
October 20	Stricter social distancing recommendations in Uppsala län
October 22	The recommendations for anyone aged over 70 years old to minimize physical interactions is lifted
October 27	Stricter social distancing recommendations in Skåne län
October 29	Stricter social distancing recommendations in Stockholms län, Västra Götalands län and Östergötlands län
November 3	Stricter social distancing recommendations in Jönköpings län, Hallands län and Örebro län
November 3	Limitation of the number of allowed people seated at the same table in restaurants to 8
November 5	Sharper social distancing recommendations in Kronobergs län and Södermanlands län
November 10	Stricter social distancing recommendations in Kalmar, Norrbotten and Västerbottens län
November 19	Stricter social distancing recommendations in Jämtlands län
November 20	Interdiction to serve alcohol after 22 pm
November 20	Interdiction to organize public gatherings and events with more than 8 participants
November 20	Recommendations to plan to avoid crowding for Christmas shopping
December 1 st	Stricter social distancing recommendations in Blekinge län

Political decisions in the UK during COVID-19

The UK Government used various restrictions to stop the spread of COVID-19. The main focus was on restricting people of different households mixing together by advising citizens to work from home and avoid the use of public transport unless necessary. There were also measures in place prohibiting inside and outside gatherings of people, at times these even included a ban on more

than two people from different households meeting outside. It should be noted that while there were general instructions for all citizens of the UK, the governments of England, Scotland, Wales, and Northern Ireland all implemented different additional restrictions. Table 3 summarises the restrictions set out by the UK Government for the period March 2021 to December 2021.

Table 7. *List of recommendations and restrictions in the UK during COVID-19*

In effect (2020)	Recommendation or restriction
23 rd March – 13 th May	National lockdown
14 th September	Gatherings of more than six people banned
18 th September	Businesses selling food or drinks to make sure of appropriate distance between tables and not allowed to serve groups larger than six.
September and October	Tier system in place
23 rd October- 9 th November	Wales goes into lockdown
4 th November- 2 nd December	National lockdown
2 nd December	Tier system in place

References

- Folkhälsomyndigheten. (2020a). *Decision on stricter general advice in Kronoberg and Södermanland counties*. <https://www.folkhalsomyndigheten.se/nyheter-och-press/nyhetsarkiv/2020/november/beslut-om-skarpta-allmanna-rad-i-kronobergs-och-sormlands-lan/>
- Folkhälsomyndigheten. (2020b). *Decision on stricter general advice in Uppsala County*. <https://www.folkhalsomyndigheten.se/nyheter-och-press/nyhetsarkiv/2020/oktober/beslut-om-skarpta-allmanna-rad-i-uppsala-lan/>
- Folkhälsomyndigheten. (2020c). *Decision on stricter general councils in the counties of Kalmar, Norrbotten and Västerbotten*. <https://www.folkhalsomyndigheten.se/nyheter-och-press/nyhetsarkiv/2020/november/beslut-om-skarpta-allmanna-rad-i-kalmars--norrbotens--och-vasterbottens-lan/>
- Folkhälsomyndigheten. (2020d). *Decisions on stricter general councils in Jönköping County, Halland County and Örebro County*. <https://www.folkhalsomyndigheten.se/nyheter-och-press/nyhetsarkiv/2020/november/beslut-om-skarpta-allmanna-rad-i-jonkopings-lan-hallands-lan-och-orebro-lan/>
- Folkhälsomyndigheten. (2020e). *Decisions on stricter general councils in Stockholm County, Västra Götaland County and Östergötland County*. <https://www.folkhalsomyndigheten.se/nyheter-och-press/nyhetsarkiv/2020/oktober/beslut-om-skarpta-allmanna-rad-i-stockholms-lan-vastra-gotalands-lan-och-ostergotlands-lan/>
- Folkhälsomyndigheten. (2020f). *Efforts are required to reduce the spread of infection with increased travel*. <https://www.folkhalsomyndigheten.se/nyheter-och-press/nyhetsarkiv/2020/juni/insatser-kravs-for-dampad-smittspridning-vid-okat-resande/>
- Folkhälsomyndigheten. (2020g). *Higher education institutions and upper secondary schools are now encouraged to conduct distance education*. <https://www.folkhalsomyndigheten.se/nyheter-och-press/nyhetsarkiv/2020/mars/larosaten-och-gymnasieskolor-uppmanas-nu-att-bedriva-distansundervisning/>
- Folkhälsomyndigheten. (2020h). *It is important that everyone takes responsibility when general*

- advice is changed for people who are 70 years and older. It is important that everyone takes responsibility when general advice is changed for people who are 70 years and older*
- Folkhälsomyndigheten. (2020i). *Local general advice in case of outbreak of covid-19.*
<https://www.folkhalsomyndigheten.se/nyheter-och-press/nyhetsarkiv/2020/oktober/lokala-allmanna-rad-vid-utbrott-av-covid-19/>
- Folkhälsomyndigheten. (2020j). *New general advice: Keep your distance and take personal responsibility.* <https://www.folkhalsomyndigheten.se/nyheter-och-press/nyhetsarkiv/2020/april/nya-allmanna-rad-hall-avstand-och-ta-personligt-ansvar/>
- Folkhälsomyndigheten. (2020k). *New phase requires new efforts against covid-19.*
<https://www.folkhalsomyndigheten.se/nyheter-och-press/nyhetsarkiv/2020/mars/ny-fas-kraver-nya-insatser-mot-covid-19/>
- Folkhälsomyndigheten. (2020l). *New regulations and general advice for restaurants.*
<https://www.folkhalsomyndigheten.se/nyheter-och-press/nyhetsarkiv/2020/november/nya-foreskrifter-och-allmanna-rad-till-serveringsstallen/>
- Folkhälsomyndigheten. (2020m). *New restaurant law will contribute to reducing the spread of covid-19.* <https://www.folkhalsomyndigheten.se/nyheter-och-press/nyhetsarkiv/2020/juli/ny-restauranglag-ska-bidra-till-minskad-spridning-av-covid-19/>
- Folkhälsomyndigheten. (2020n). *Nya Allmänna Råd: Håll Avstånd Och Ta Personligt Ansvar.*
<https://www.folkhalsomyndigheten.se/nyheter-och-press/nyhetsarkiv/2020/april/nya-allmanna-rad-hall-avstand-och-ta-personligt-ansvar/>
- Folkhälsomyndigheten. (2020o). *People over 70 should limit social contacts until further notice.*
<https://www.folkhalsomyndigheten.se/nyheter-och-press/nyhetsarkiv/2020/mars/personer-over-70-bor-begransa-sociala-kontakter-tills-vidare/>
- Folkhälsomyndigheten. (2020p). *Proposal: Additional restrictions on public gatherings.*
<https://www.folkhalsomyndigheten.se/nyheter-och-press/nyhetsarkiv/2020/mars/forslag-ytterligare-begransningar-av-allmanna-sammankomster/>
- Folkhälsomyndigheten. (2020q). *Proposal: No general meetings with more than 500 people.*
<https://www.folkhalsomyndigheten.se/nyheter-och-press/nyhetsarkiv/2020/mars/forslag-inga-allmanna-sammankomster-med-fler-an-500-personer/>
- Folkhälsomyndigheten. (2020r). *Proposal that the visit ban on special housing should end.*
<https://www.folkhalsomyndigheten.se/nyheter-och-press/nyhetsarkiv/2020/september/forslag-om-att-besöksförbudet-på-sarskilda-boenden-ska-upphora/>
- Folkhälsomyndigheten. (2020s). *The upper secondary schools can open until the autumn term.*
<https://www.folkhalsomyndigheten.se/nyheter-och-press/nyhetsarkiv/2020/maj/gymnasieskolorna-kan-oppna-till-hostterminen/>
- Folkhälsomyndigheten. (2020t). *Think about whether the trip is really necessary.*
<https://www.folkhalsomyndigheten.se/nyheter-och-press/nyhetsarkiv/2020/mars/tank-over-om-resan-verkligen-ar-nodvandig/>
- Regeringskansliet. (2020a). *Maximum of eight people at public gatherings and public events.*
<https://www.regeringen.se/pressmeddelanden/2020/11/max-atta-personer-vid-allmanna-sammankomster-och-offentliga-tillställningar/>
- Regeringskansliet. (2020b). *Prohibition on alcohol sales from 10 pm.*
<https://www.regeringen.se/pressmeddelanden/2020/11/forbud-mot-alkoholforsaljning-fran-klockan-22/>
- Rijksoverheid. (2020a). *Additional measures for education, catering, sports.*
<https://www.rijksoverheid.nl/onderwerpen/coronavirus-covid-19/nieuws/2020/03/15/aanvullende-maatregelen-onderwijs-horeca-sport>
- Rijksoverheid. (2020b). *As of July 1: 1.5 meters remains the norm.*
<https://www.rijksoverheid.nl/actueel/nieuws/2020/06/24/per-1-juli-1-5-meter-blijft-norm>
- Rijksoverheid. (2020c). *Avoid crowds, keep 1.5 meters away.*

<https://www.rijksoverheid.nl/actueel/nieuws/2020/05/06/vermijd-drukke-houd-15-meter-afstand>

Rijksoverheid. (2020d). *Corona approach: the next step.*

<https://www.rijksoverheid.nl/actueel/nieuws/2020/05/19/corona-aanpak-de-volgende-stap>

Rijksoverheid. (2020e). *Corona measures extended.*

<https://www.rijksoverheid.nl/actueel/nieuws/2020/04/21/maatregelen-corona-verlengd>

Rijksoverheid. (2020f). *New measures against the spread of coronavirus in the Netherlands.*

[https://www.rijksoverheid.nl/onderwerpen/coronavirus-covid-](https://www.rijksoverheid.nl/onderwerpen/coronavirus-covid-19/nieuws/2020/03/12/nieuwe-maatregelen-tegen-verspreiding-coronavirus-in-nederland)

[19/nieuws/2020/03/12/nieuwe-maatregelen-tegen-verspreiding-coronavirus-in-nederland](https://www.rijksoverheid.nl/onderwerpen/coronavirus-covid-19/nieuws/2020/03/12/nieuwe-maatregelen-tegen-verspreiding-coronavirus-in-nederland)

Rijksoverheid. (2020g). *Partial lockdown continues.*

[https://www.rijksoverheid.nl/onderwerpen/coronavirus-covid-](https://www.rijksoverheid.nl/onderwerpen/coronavirus-covid-19/nieuws/2020/11/17/gedeeltelijke-lockdown-gaat-verder)

[19/nieuws/2020/11/17/gedeeltelijke-lockdown-gaat-verder](https://www.rijksoverheid.nl/onderwerpen/coronavirus-covid-19/nieuws/2020/11/17/gedeeltelijke-lockdown-gaat-verder)

Rijksoverheid. (2020h). *Partial lockdown to reduce infections.*

[https://www.rijksoverheid.nl/actueel/nieuws/2020/10/13/gedeeltelijke-lockdown-om-](https://www.rijksoverheid.nl/actueel/nieuws/2020/10/13/gedeeltelijke-lockdown-om-besmettingen-terug-te-dringen)

[besmettingen-terug-te-dringen](https://www.rijksoverheid.nl/actueel/nieuws/2020/10/13/gedeeltelijke-lockdown-om-besmettingen-terug-te-dringen)

Rijksoverheid. (2020i). *Temporary strengthening of the partial lockdown.*

[https://www.rijksoverheid.nl/onderwerpen/coronavirus-covid-](https://www.rijksoverheid.nl/onderwerpen/coronavirus-covid-19/nieuws/2020/11/03/tijdelijke-verzwaring-van-de-gedeeltelijke-lockdown)

[19/nieuws/2020/11/03/tijdelijke-verzwaring-van-de-gedeeltelijke-lockdown](https://www.rijksoverheid.nl/onderwerpen/coronavirus-covid-19/nieuws/2020/11/03/tijdelijke-verzwaring-van-de-gedeeltelijke-lockdown)

Rijksoverheid. (2020j). *Tightened measures to control the coronavirus.*

[https://www.rijksoverheid.nl/onderwerpen/coronavirus-covid-](https://www.rijksoverheid.nl/onderwerpen/coronavirus-covid-19/nieuws/2020/03/23/aangescherpte-maatregelen-om-het-coronavirus-onder-controle-te-krijgen)

[19/nieuws/2020/03/23/aangescherpte-maatregelen-om-het-coronavirus-onder-controle-te-krijgen](https://www.rijksoverheid.nl/onderwerpen/coronavirus-covid-19/nieuws/2020/03/23/aangescherpte-maatregelen-om-het-coronavirus-onder-controle-te-krijgen)