Google Mobility and COVID-19 in London, England and Toronto, Canada

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BACKGROUND

Restrictive measures implemented in response to the COVID-19 pandemic have triggered abrupt and large-scale changes in human travel behaviours all around the world and in Canada (1-3). Given fluctuations in COVID-19 cases and severity brought on by subsequent waves, strain mutations, and reactive public health measures to these changes, it has been unclear to what extent population-level mobility has been changing over time.

The implications of restricted mobility are expansive, as they impact personal, occupational, and economic facets of society (4, 5). Moreover, public transit sectors and businesses in retail, recreation and hospitality were hit particularly hard by lock-down measures and distancing mandates, with disproportionate impacts on large cities (5, 6). However, little information has been processed and made public to track changes in mobility with respect to COVID-19 cases. Nor has the data been made public to evaluate the return to 'normal' as more protective health measures, vaccinations and medications come to market.

This report will examine changes in public mobility to various points of interest in major global cities, focusing on the Census Metropolitan Area (CMA) of Toronto, Canada and Greater London (GL), England. The purpose of this report is to remedy the lack of publicly available information on mobility patterns in these spaces, and how those patterns line up with government policies (e.g., lockdowns, reopening's, mandatory mask mandates); COVID-19 (cases, deaths) and vaccination milestones (vaccination by age groups). Specifically in hard-hit sectors (e.g., retail, public transit etc.), it is important to monitor if they have had a return of pedestrian traffic to pre-pandemic levels. Thus, the objectives of this report are to plot trends in mobility from the beginning of the pandemic and to compare COVID-19 case counts and deaths over time for Toronto and London, with regard to policy, vaccinations, and time. The report will also explore changes in mobility within retail, transportation, park spaces and time spent in residential settings during the course of the pandemic.

Methods:

COVID-19 case counts are at the Public Health Unit-level for the CMA of Toronto and sourced from the Government of Ontario's website (<u>https://data.ontario.ca/dataset/status-of-covid-19-cases-in-ontario-by-public-health-unit-phu</u>). Toronto, Halton, Peel, and York region Public Health Units were included. The COVID-19 data for the GL area was sourced from the government of London's website (<u>https://data.london.gov.uk/dataset/coronavirus--covid-19-cases</u>). Event lines specifying government policy (lockdowns, openings, extensions, masking), vaccination milestones by age groups for Ontario were sourced from consulting firms (<u>https://www.mccarthy.ca/en/insights/articles/covid-19-emergency-</u>

<u>measures-tracker</u>), government (<u>https://covid-19.ontario.ca/ontarios-covid-19-vaccination-plan; https://health-infobase.canada.ca/covid-19/vaccination-coverage/</u>) and news sources (<u>https://toronto.ctvnews.ca/ontario-administers-first-doses-of-covid-19-vaccine-in-toronto-1.5230004</u>). For GL, they were sourced from international consulting (<u>https://bfpg.co.uk/2020/04/covid-19-timeline/</u>) and news

(https://www.standard.co.uk/news/health/covid-timeline-uk-lockdown-vaccine-pandemic-borisjohnson-b923362.html) sources. Cumulative daily covid cases and cumulative weekly deaths were available for GL. For Ontario, cumulative death and resolved cases were used to back calculate daily cases. Cumulative deaths were used to obtain daily deaths.

Mobility data used on cellphone locations were provided by Google – 'COVID-19 Community Mobility Reports' (<u>https://www.google.com/covid19/mobility/</u>), predominantly acquired through Android devices and Google Maps Location History from February 2020 onwards (7). The data provided shows a relative change (unit of change expressed as a percentage) to the baseline (a 5-week pre-pandemic period from January 3rd to February 6th, 2020) (7). Comparisons are made by region and day-of-the-week. The mobility metrics are as defined by Google, measure differences in traffic volume from baseline in various categories of places with the exception of the *Residential* category (which measures time spent indoors, in places categorized as residential) (8). The data is interpreted with the mobility Index of 100% (0% in the plots) meaning no changes occurred from the baseline period; anything less than 100% (minus % values) illustrating a decrease from baseline and anything greater than 100% (positive % value) an increase from baseline (8). The data provided were at the Public Health Unit level in the GTA and at the borough level in the GL. Due to large populations surrounding the London core, borough-level data was aggregated up to the sub-regional level using census population counts to weight the mobility data by those regions, thereby making them more comparable to Toronto regions.

The categories for various places of mobility were created by Google and are (8):

- Retail & recreation: Mobility trends for places like restaurants, cafes, shopping centers, theme parks, museums, libraries, and movie theaters (i.e., non-essential).
- <u>Grocery & pharmacy</u>: Mobility trends for places like grocery markets, food warehouses, farmers markets, specialty food shops, drug stores, and pharmacies (i.e., essential locations).
- <u>Parks</u>: Mobility trends for places like national parks, public beaches, marinas, dog parks, plazas, and public gardens.
- Transit stations: Mobility trends for public transport hubs, subways, buses, and train stations.
- Workplaces: Mobility trends for places of work.
- <u>Residential</u>: Mobility trends for places of residence.

Grocery & pharmacy was excluded from the report as it shows mobility in predominantly essential locations, not affected by pandemic lockdowns. Workplaces were excluded as the definition provided by Google is quite vague. It is not clear if they are a place of work for all types of employment, including essential workplaces or only office jobs, etc., therefore excluded from this report.

The categories for identifying changes in government policy reflected in closures, closure extensions, reopening, mask mandates and vaccinations:

✤ <u>Red :</u>: Closers

- ✤ <u>Orange :</u>: Closure extensions
- ✤ <u>Green</u>: Reopening/easing of restrictions
- ✤ <u>Blue</u>: Mandatory mask mandates
- ✤ <u>Black</u>: Major vaccine milestones

Vertical lines associated with these categories are plotted in each graph.

Analysis:

Data manipulations were carried out and plots generated inside of SAS 9.4. Plots were generated using the PROC SGPLOT LOESS procedure and smoothing (value 0.1) applied to improve legibility and interpretability. Both relative changes in mobility and daily COVID-19 case counts and deaths over time were provided on the same plots. These graphs represent nearly a 2-year time period from February 2020 to November 2021. Given the highly dynamic situation presented by COVID-19 and constant shifts in policy, the authors made attempts to select only the most significant events (e.g., province-wide shutdowns), therefore, it should be noted that this is not an exhaustive list of policy over the pandemic period. In some instances, multiple policy announcements were made in close succession, for example, back-to-back closures in different public health units or boroughs, often we chose the average of the dates. In both jurisdictions, and especially in London, UK, lockdowns were imposed on specific hot spots/boroughs using a 'tiered approach' and at different times, therefore, our event lines may not perfectly line up with every sub-region at a given point in time. For policy around mask mandates, we plotted all events to demonstrate that they came into effect of each other in close succession, regardless of the region (both in Toronto and London).

RESULTS:

COVID-19 Cases (Toronto CMA)

In examining daily COVID-19 cases over the reported period, three distinct waves are observed with a potential fourth wave which appears to have been delayed or averted. The plot below suggests a first wave between April and August of 2020. The second wave occurred between September 2020 and February 2021 and a third wave between March and July 2021. A small swell pattern is observable between August and November 2021, it is not clear at this point in time if this is signs or beginnings of a fourth wave. Regional variations in daily covid cases are heterogeneous by Public Health Units with Toronto and Peel regions experiencing the largest daily case counts, especially within the second and third wave of the pandemic. In the height of the third wave, Toronto Public Health was experiencing over a 1000 cases per day and Peel nearly 800 cases per day.



In the plot below, event lines are added to track various government policies and responses to the COVID-19 pandemic, including closures, extension of closures, reopening's, mask mandates, and vaccine rollouts. Lockdowns were imposed on March 23rd, 2020, with several extensions over May and June. Public mask mandates came into effect across the four regions in roughly the same time: first in Peel (June 30th) (9), then Toronto (July 7th) (10), York (July 17th) (11) and finally Halton (July 22nd) (12). There was continued easing of restrictions in September and October 2020, and a province-wide shut-down December 21st as cases dramatically rose during the fall and holiday period. First public does of a COVID-19 vaccine was administered mid December 2020. Lockdowns continued into April and May of 2021, as Ontario saw its highest daily cases to date. At around the same time, vaccinations began to roll out to various segments of the general population, typically starting from older age cohorts and downwards to younger age groups. Some hotspots saw earlier rollout of vaccinations usually administered from older to younger age cohorts but not always, depending on supply at the time. By the end of May 2021, over 50% of adults 18 years of age and over had received one dose. As of June 19th, 57% of 12–17-year-old received a first dose. Additionally, the government began to lift many restrictions around gatherings, dining, and other services (e.g., gyms). Ontario reached a major vaccination milestone by early October 2021, where over 75% of the adult population were double vaccinated and again in early November 2021 where over 80% of the eligible population (over the age of 12) received two doses. In approximately 11-months 80% of the eligible Ontario population (12-years and up) had received 2 doses of vaccines. Drastic drop in cases were observed between vaccination points 2, 3, and 4 timelines.



COVID-19 Deaths (Toronto CMA)

It is also crucial to look at COVID-19 deaths over this time. Deaths were highest in the Toronto Public Health Unit in all waves of the pandemic. The highest daily rate of deaths was observed in Jan-February 2021, even though cases had not reached their peak. Of some reassurance, even though the third wave had the highest daily case counts, deaths dropped, the peak was less than half of the previous peak in the second wave. This trend was possibly due to increased immunity brought on by vaccinations in the most vulnerable groups, some in the general population and regrettably deaths in the most vulnerable. Peel Region showed the highest rates of daily deaths in Aug-September 2021 despite the drop in other jurisdictions. Notwithstanding this trend, their daily rates of death continue to decline similar to other jurisdictions.



Mobility (Toronto CMA)

In examining population mobility throughout the pandemic, 'Retail and Recreation' is an important indicator as it reflects movement patterns in largely non-essential sectors of the goods/services economy. The largest reduction in foot-traffic was observed after the initial lockdown in Mar-April 2020. Mobility begins to rise without any major lifting of restrictions. Despite modified reopening's by region in Sep-October 2020, mobility largely begins to drop as cases begin to rise. In contrast, time spent in residential begins to rise. This is likely mediated through seasonality as it begins to get colder. Mobility had already begun to drop before the December 2020 lockdown was made public, however, the announcement likely further decreased mobility. During this time, people in the four public health units increased their relative daily hours spent at home by about 20% to pre-pandemic levels. Despite government policies and continuation of closures, mobility outside the home saw an increase in March 2021 which fell again due to additional restrictions and high case counts brought on by wave 3. After the third wave, likely a combination of warmer months ahead, rapid vaccinations, and reopening of closed sectors in June 2021, pushed mobility to its highest since the beginning of the pandemic. Traffic seems to be sustained as of November 2021 in comparison to the previous year when it began to drop. Additionally, time spent in residential settings is increasing at a much slower rate than the previous year. Similar patterns are observed in retail traffic. While the change is partly due to the colder weather, the difference in mobility in fall 2021 relative to fall 2020 is likely due to widespread vaccinations and less restrictions.





Parks give us some interesting indications around alternate outdoor activities during heavy lockdowns, high case counts, and seasonal changes. The strongest indicator of park use was the seasons. Warmer months peaking around August had the highest rate of park visits. This makes sense as the Park category also includes outdoor spaces such as beaches. During the first wave, parks saw over 200% relative increase in York region. In Toronto and Peel region, park use nearly doubled during this time. After every lockdown, we see some upward trending in park visits. It is hard to say whether daily cases, lockdowns or both influenced increased park visits. Nevertheless, parks appear to be important spaces in which public traffic could be diverted to when all other sectors are closed, providing alternate outdoor activities to the public.



Relative changes in mobility to transit facilities demonstrate drastic drops in foot traffic to those destinations. Relative transit use remains 40% lower than pre-pandemic levels for all four regions. Transit use appears to have been largely impacted by daily cases. However, visit to transit locations seem to be at it's highest, especially in Toronto, since the beginning of the pandemic. The increase is partially seasonal, and possibly due to increased vaccinations, reopening's and some sectors returning to work. Unfortunately, overall traffic remains 40% lower relative to pre-pandemic periods.



Relative changes in residential settings, demonstrate the additional time spent at home, which typically is within private dwellings. There is a strong homogenous pattern between regions and compliance with stay-at-home orders. Generally speaking, in the first wave people spent up to 30%

more time per day, at home relative to baseline. However, it appears that with every subsequent wave and lock-down, compliance or the relative time spent at home is diminished. Despite, the third wave having the largest daily case counts, time spent at home was approximately 12-15% lower than the year prior, where compliance was highest.



COVID-19 Cases (London U.K. Boroughs by Sub-Regions):

Sub-region	London boroughs	
<u>Central</u>	<u>Camden, City of London, Kensington and Chelsea, Islington,</u> Lambeth, Southwark, Westminster	NORTH WEST EAST CENTRAL
<u>East</u>	Barking and Dagenham, Bexley, Greenwich, Hackney, Havering, Lewisham, Newham, Redbridge, Tower Hamlets, Waltham Forest	
<u>North</u>	Barnet, Enfield, Haringey	A STAND S STA
<u>South</u>	<u>Bromley, Croydon, Kingston upon Thames, Merton, Sutton, Wandsworth</u>	SOUTH
West	Brent, Ealing, Hammersmith and Fulham, Harrow, Richmond upon Thames, Hillingdon, Hounslow	

Source: (https://en.wikipedia.org/wiki/List of sub-regions used in the London Plan#cite note-Places-6)

Daily COVID-19 cases in sub-regions of London show a first wave between February and June 2020. A major second wave between September 2020 and May 2021. A potential third wave starting around June 2021 which is currently in development. It is uncertain if the third wave is diminishing or making a resurgence. We noted a deal of heterogeneity between the Eastern region versus other subregions accounting for a large proportion of daily cases, especially in the second wave. The largest daily cases were observed in the East region during the second wave around January 2021.



COVID-19 Deaths (London U.K. Boroughs by Sub-Regions)

Looking at COVID-19 deaths over this time, the first wave of the pandemic had a large number of casualties despite the low number of cases reported. It is not entirely clear if the lack of testing capacity in the first wave of the pandemic was a result of politics, individual privacy, slow authorization of laboratories, poor management, or global disruptions in logistics and supply of testing materials, or a combination of all factors (13, 14). Not surprising that deaths were highest late January 2021, especially in the East region, following the large upsurge of cases in the second wave. At this time the East region had over 400 deaths per week. It remains a positive sign that deaths have remained low despite the upsurge of cases in the summer/fall 2021.



Similar to Toronto, the strongest relative decrease in visiting retail and recreational facilities was observed in the first wave around April 2020. With eased restrictions and warmer weather from May to September 2020, we see a steady increase in non-essential retail and recreation. Due to on and off placing and removing of restrictions, we see fluctuations in mobility in the retail sector, all the while cases increased in the second wave as the government promised to allow families to join for Christmas but backpedaled by applying tiered lockdowns in specific hotspots (14). This may have had unintended consequences of growing cases with too little too late attempt to backtrack. Subsequent changes in mobility to retail and recreational outlets showed diminishing traffic in early November 2020, slightly increasing in December, and back down during the imposed lockdown in January 2021. A major lockdown is imposed in the new year of 2021 as cases reached their highest since the pandemic began. Major closures, clearly have noticeable impacts on mobility to the retail sector. As vaccinations reach more of the population, and warmer weather arrives, despite continuation of lockdowns, mobility begins to increase. The increase continues as more vaccinations are administered and restrictions removed. In June 2021, many covid restrictions were removed and masks became optional in many public settings (15). To date, it appears that traffic to these destinations has reached within approximately 10% of pre-pandemic levels. Despite the regional heterogeneity, Central London appears to have the largest reduction in retail traffic over time. It is not clear why but perhaps it may be partly due to reduced transit use which may be a primary means of travel to Central London from other subregions.



Transit facilities saw major reductions in foot traffic. During the first wave, relative traffic dropped by approximately 75% for all regions. While traffic has rebounded somewhat since, it still remains about 30% lower than pre-pandemic levels. Transit in Central London appears to have caught up with other subregions.



Relative changes in added time spent within residential settings show similar patterns across regions and over time. The population spent the most time in residential settings during the first wave lockdown. There was another marked residential period between November 2020 and January 2021. There is a steady decline thereafter, as both warmer months and widespread vaccinations allow for the lifting of restrictions from April to June 2021. There was a further decline in time at home following the major lifting of restrictions in July 2021 (15). Relative to the year prior, people are spending approximately 10% less time at home. Moreover, the Central region which had the highest time spent at home, has reached similar levels to the Southern region as of October of 2021.



Parks show an interesting trend in both London and Toronto, notwithstanding the seasons impact on mobility to parks; with nearly every lockdown, traffic increases to parks and decreases with lifting of restrictions. Traffic also decreased after mask mandates in both jurisdictions. Perhaps a reflection of increased confidence entering indoor spaces.



Discussion:

From the onset of the pandemic, this report examined mobility patterns to retail, transit, parks and residential settings, and daily COVID-19 cases and deaths, within Toronto, Canada and London, U.K. To date, notable similarities and differences were identified between the two cities. In terms of daily COVID-19 case counts, it appears that Toronto experienced 3 distinct waves and potentially delayed or avoided a fourth, while London experienced two distinct waves and potentially going through a third. London experienced its worse wave in January 2021, while Toronto did so in May 2021. In comparing the second wave in London and the third in Toronto (highest for both cities on record), London had a much higher number of daily case counts. It is difficult to speculate whether this was due to more stringent lockdowns in Ontario, lower population and density, or other factors. It is also important to note differences between these two cities, with regard to vaccination rollouts, policies, and waves which likely impacted lock-down measures and subsequently mobility. Ultimately, there are promising signs that widespread COVID-19 vaccinations have drastically reduced related deaths and cases in both cities.

Policy:

Lockdown events in both jurisdictions showed to be effective in increasing time at home and reducing out of home exposure to COVID-19 when it was most needed. While the timing and scope of those lockdowns in both cities were highly political, that was beyond the scope of this report. What is clear was that they clearly had an impact on population movement, and this was evident in both jurisdictions. It should be noted however, that compliance appears to diminish with every subsequent lockdown in both jurisdictions. COVID fatigue and time at home may have been a factor. Mask mandates had little impact on mobility in either jurisdiction. We suspect that most in the general population were already wearing masks due to public health guidelines before they were made mandatory. Masks may have slightly increased transit use in London, and reduced Park use where traffic likely diverted to other areas, however, we are unable to say definitively. New policy around vaccination passports have been implemented in both settings, however, too early to include in this report.

Hard Hit Regions:

Peel Health Region in Toronto and East sub-region in London appear to have been hit particularly hard with COVID-19. In Peel, this may be partly due to a high proportion of essential and warehouse employment and cohabitation of multigenerational families and high-occupancy dwellings (16, 17). In fact the federal governmental Canada pledged \$6.5 million dollars to build quarantine facilities for families that did not have the capacity to quarantine safely at home (18, 19). Peel has a lower population count and high-density housing relative to the Toronto core. Therefore, the high number of cases relative to Toronto is of concern. Fortunately, large-scale vaccinations appear to have leveled the numbers in all regions.

The East region of London had significantly more daily cases, especially in the second wave, relative to other regions. Early evidence seems to suggest that similar factors to those in Toronto may be at play, such as high proportion of essential workers, low income groups and dense housing (20, 21). Lower incomes are also likely tied in with essential work, making it difficult to stay at home (22). Policies around sick-days, sick-pay and job security were not examined but are important issues to address. Both cases and deaths have hit these two regions much worse than other neighbouring regions in both countries. Further research into possible causes are warranted.

Mobility:

With regard to mobility data, similar patterns were observed between the two cities and changes in foot traffic to retail and recreational destinations. Both settings show that retail has not rebounded, particularly in core regions: Central London and Toronto locations. In Canada, Toronto lags behind other neighbouring regions for retail traffic relative to pre-pandemic levels. Both cities showed drastic reduction in travel to transit locations, while neither has fully recovered to pre-pandemic levels, London shows slightly better recovery. This has major implications for large urban centers in which these factors in addition to reduced tourism may pose challenges for an economic recovery.

The residential tracking of mobile devices in Toronto shows with every subsequent wave, less time spent at home. The reduction of time at home with every subsequent wave may be signs of quarantine fatigue, however, this cannot be said with certainty. There is a strong seasonal effect in both cities as people spend more time to enjoy the outdoors in the warmer months of the year. What is certain, is that Torontonians have never spent more time indoors than they have during this pandemic. Drastic reductions in physical activity are likely to result and this is alarming as most Canadians were not meeting weekly recommended activity levels prior to the pandemic (23-25). Evaluation and intervention studies should examine the extent of activity limitations as physical activity has major implications for physical and psychological health in all stages of life (26, 27).

Most notably, we noted an interesting pattern whereby mobility (specifically to non-essential) locations, would begin to drop before actual lockdowns. We cannot say definitely why this is so but speculate that many may weigh the cost-benefit of going out to public spaces based on daily cases. As daily cases rose, traffic to retail dropped in kind and vise versa (more time outside when cases were dropping). Another explanation may be that in both cities governments attempted to implement targeted lockdowns where cases were highest and the event dates we used for lockdowns did not align perfectly with every region in the cities. It should be noted that targeted lockdowns were attempted and later removed in both cities as governments soon realized that this policy would not be effective without enforcement, something neither jurisdiction was keen on due to fears of invading individual freedoms, rights to mobility, and privacy. The other clear indicators of mobility were hard lockdowns and reopening's. Every major lockdown had diminished compliance in terms of hours spend in residential locations. This could potentially be due to COVID-fatigue or other factors. Research in this area may be able to explore this subject further. This has important implications for

policy and strategies aimed at using lockdowns in the future. Lastly, the seasons had a clear impact on mobility, especially to parks. Parks also showed to be important public spaces and due to greater safety from COVID transmission outdoors, were able to supplement mobility where restrictions were highest indoors and in other indoor public spaces. Parks may have supplemented physical activity in the population where other avenues were unavailable. The psychological benefits of parks, especially during peaks of COVID have not been examined. Lastly, park use in York and Halton (contain more rural communities) was double compared to Toronto and Peel (contain more urban communities). Regional variation in park use was not so clear cut in London, however, West London appears to have the highest use of parks. Perhaps due to the merging of boroughs we may have lost some granularity in London. Ultimately, how we think about green spaces and how this growth in park use benefited the populace in both cities should be explored. Future studies should aim to explore some these observed trends in greater detail and their impact on mental and physical health.

Concluding remarks:

This report was an exploratory examination of COVID-19 cases and deaths, with regard to population mobility trends in Toronto, Ontario and London, England. While much of the findings are descriptive and exploratory in nature, they still give some valuable insights on the state of traffic into various segments of society over time. This report also offers some insights into interesting population-level patterns and behaviours that warrant more targeted and methodical studies.

Since the pandemic began, both cities experienced distinct COVID-19 waves with high case counts and casualties. However, London did have much higher cases during the peak of COVID, the difference likely due to higher population count and density. It is positive to see that both cities also experienced drastic drop in cases and deaths, largely due to highly ambitious and successful vaccination campaigns. Both cities implemented mandatory masks in public spaces, the impact of which is unclear, especially because they were already recommended by public health before becoming law. The literature revealed that both governments implemented lockdowns when absolutely necessary and this had a direct impact on mobility, while the impact on cases was less clear based on this report. Troubling was that in both cities but especially in London, governments attempted to either balance lockdowns with easing or restrictions or targeted and tiered approach to lockdowns which likely created confusion, fatigue, and porous boundaries which likely did not have the desired impact. More research is needed in this area as there are key lessons and takeaways that must be acknowledged and used to bolster the policy toolkit and pandemic playbook during this recovery and for future pandemics.

Both cities also had regions where cases and deaths were disproportionality higher than neighbouring regions, early evidence seems to suggest it is a combination of dense living arrangements, low-income families, and essential work were the cause of these disparities. Research in this area is ongoing and continues to develop. What is clear is that mobility changed in both cities over time. Large-scale lockdowns were effective at reducing mobility or diverting it from high-risk public spaces. What is interesting to explore, is how and why population mobility begins to increase despite lifting of restrictions? Why with every subsequent lockdown that relative time at home is diminished? Also,

how individuals in the public make daily personal decisions about mobility to public spaces as the pandemic develops? There may be some indications here that over time case counts can be a strong indicator of mobility. As cases rose sharply mobility would drop, even before any major lockdowns. The role of the media and daily reporting of cases should be examined. There were also indications of COVID-fatigue. As the pandemic moved forward, even as cases and deaths surpassed previous waves, mobility continued to increase in sectors outside of the home. Clearly, more research is needed in this multifaceted phenomenon that is the pandemic. Lastly, we need to monitor the economic recovery in cities and use of public transit facilities, which are still experiencing lower mobility levels than prepandemic times. There are key lessons and takeaways that must be acknowledged and used to bolster the policy toolkit and pandemic playbook during the recovery from this and future pandemics.

References:

1. Barbieri DM, Lou B, Passavanti M, Hui C, Hoff I, Lessa DA, et al. Impact of COVID-19 pandemic on mobility in ten countries and associated perceived risk for all transport modes. PLoS One. 2021;16(2):e0245886.

2. Brown KA, Soucy JR, Buchan SA, Sturrock SL, Berry I, Stall NM, et al. The mobility gap: estimating mobility thresholds required to control SARS-CoV-2 in Canada. CMAJ. 2021;193(17):E592-E600.

3. Pepe E, Bajardi P, Gauvin L, Privitera F, Lake B, Cattuto C, et al. COVID-19 outbreak response: a first assessment of mobility changes in Italy following national lockdown. medRxiv. 2020:2020.03.22.20039933.

4. Prati G, Mancini AD. The psychological impact of COVID-19 pandemic lockdowns: a review and metaanalysis of longitudinal studies and natural experiments. Psychol Med. 2021;51(2):201-11.

5. Canada P. The impact of the pandemic on the downtown areas of Canada's six major cities. Montreal, Quebec; 2021 March, 22, 2021.

6. Canada S. COVID-19 in Canada: A One-year Update on Social and Economic Impacts. Ottawa, ON: Statistics Canada; 2021.

7. R. K. Mobility Changes in Ontario – Mobility Tool: Technical Document. Toronto, ON:; 2021.

8. Google. COVID-19 Community Mobility Report: Canada. California: Google; 2021.

9. Sundaresan S. Peel takes first step toward mandatory non-medical masks Toronto, ON: Region of Peel; 2020 [updated June 30, 2020. Available from:

https://www.peelregion.ca/news/archiveitem.asp?year=2020&month=5&day=30&file=2020530.xml.

10. Toronto Co. City of Toronto makes masks or face coverings mandatory in enclosed public spaces Toronto, ON: City of Toronto; 2020 [updated June 30, 2020. Available from: <u>https://www.toronto.ca/news/city-of-toronto-makes-masks-or-face-coverings-mandatory-in-enclosed-public-spaces/</u>.

11. Casey P. Face mask or covering mandatory in York Region effective Friday, July 17, 2020 Toronto, ON: York Region; 2020 [updated July 09, 2020. Available from:

https://www.york.ca/wps/portal/yorkhome/newsroom/mediarelease/facemaskorcoveringmandatoryinyorkreg ionjuly172020/!ut/p/z1/tZzLU8MgFIV_iwuXGQghQJdprEZrrM_aZuPQIEQ0IZVia_z1Uvfacexlw_D67pkDzBxU0Bk qjNzoWjrdGdn48bxgT4RQloUpvsCj2xifT8_z4TCjEcYMTVGBilWpl2gekZhWmIfBgBEW0EVMAsEXUTCgAxovIFCCVL vdpXEr94zmvX0qO-OUcce47-yrH6yddu_fE7JpWrXU0qpGybVaH-

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ODQDz4qrthVRH5jP4VVwli7E9r5qD9b1UVMnR0dfl6M8gQ!!/dz/d5/L2dBISEvZ0FBIS9nQSEh/

12. Winkels J. Halton Regional Council adopts mandatory mask by-law Toronto, ON: Halton Region; 2020 [updated July 17, 2020. Available from: <u>https://www.halton.ca/The-Region/News/2020/Halton-Regional-Council-adopts-mandatory-mask-by-l</u>.

13. Clark P, Cookson C, Hughes L. How the UK got coronavirus testing wrong. Financial Times. 2020.

14. B D. A timeline of the year since the UK officially went into lockdown London, UK: Evening Standard; 2021 [updated March 23, 2021. Available from: <u>https://www.standard.co.uk/news/health/covid-timeline-uk-lockdown-vaccine-pandemic-boris-johnson-b923362.html</u>.

15. Evie A. COVID-19 Timeline London, UK: The British Foreign Policy Group; 2021 [updated November 15, 2021. Available from: <u>https://bfpg.co.uk/2020/04/covid-19-timeline/</u>.

16. Ghosh AK, Venkatraman S, Soroka O, Reshetnyak E, Rajan M, An A, et al. Association between overcrowded households, multigenerational households, and COVID-19: a cohort study. medRxiv. 2021:2021.06.14.21258904.

17. van Ingen T, Akingbola S, Brown KA, Daneman N, Buchan SA, Smith BT. Neighbourhood-level risk factors of COVID-19 incidence and mortality. medRxiv. 2021:2021.01.27.21250618.

Mancini M. In one of Ontario's hardest-hit regions, COVID-19 takes a toll on essential workers. CBC.
2021.

19. Ogilvie M. Hard-hit Peel Region to get COVID-19 isolation facility for those unable to quarantine at home. Toronto Star. 2020.

20. HUI S. 'Eye of the storm': Diverse east London grapples with virus. AP News. 2021.

21. Mohdin A. 'Every day I hear about a Covid-19 death': life in the UK's worst-affected area. The Guardian. 2020.

22. Wire AN. 'Eye of the storm': Diverse east London grapples with virus. Independent. 2021.

23. Di Sebastiano KM, Chulak-Bozzer T, Vanderloo LM, Faulkner G. Don't Walk So Close to Me: Physical Distancing and Adult Physical Activity in Canada. Frontiers in Psychology. 2020;11(1895).

24. Moore SA, Faulkner G, Rhodes RE, Vanderloo LM, Ferguson LJ, Guerrero MD, et al. Few Canadian children and youth were meeting the 24-hour movement behaviour guidelines 6-months into the COVID-19 pandemic: Follow-up from a national study. Applied Physiology, Nutrition, and Metabolism. 2021;46(10):1225-40.

25. Ross R, Chaput J-P, Giangregorio LM, Janssen I, Saunders TJ, Kho ME, et al. Canadian 24-Hour Movement Guidelines for Adults aged 18–64 years and Adults aged 65 years or older: an integration of physical activity, sedentary behaviour, and sleep. Applied Physiology, Nutrition, and Metabolism. 2020;45(10 (Suppl. 2)):S57-S102.

26. Janssen I, Leblanc AG. Systematic review of the health benefits of physical activity and fitness in schoolaged children and youth. Int J Behav Nutr Phys Act. 2010;7:40.

27. Warburton DER, Bredin SSD. Health benefits of physical activity: a systematic review of current systematic reviews. Curr Opin Cardiol. 2017;32(5):541-56.