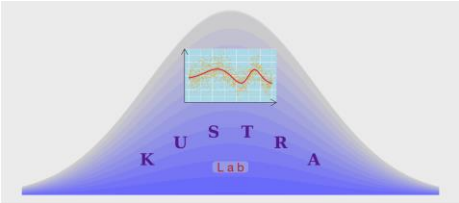

Mobility Changes in Ontario - Mobility Tool: Technical document

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Authors

Dr. Rafal Kustra, PhD
Associate Professor
Dalla Lana School of Public Health
University of Toronto

Contact

For more information about the Mobility Changes in Ontario – Mobility Tool, please contact r.kustra@utoronto.ca.

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Introduction

The creation of the Mobility Changes in Ontario – Mobility Tool (Mobility Tool) allows users to generate graphs displaying overall mobility changes in Ontario during the COVID-19 pandemic (March 2020 to present). The purpose of this document is to describe the technical aspects of the Mobility Tool.

COVID-19 is a respiratory illness that is transmitted through the spread of the virus SARS-CoV-2. SARS-CoV-2 spreads between people who are in close contact with each other, through respiratory droplets and aerosols projected by the infected person. Because aerosols can remain suspended in air and travel farther than one metre, SARS-CoV-2 is spread in crowded indoor settings or areas with poor ventilation.

To limit the spread of SARS-CoV-2, the Government of Ontario implemented various measures, such as stay-at-home orders, to restrict close contact of individuals outside of their own household. Mobility data collected from cell phones can provide information on changes in movement in Ontario. This data is important for a retrospective understanding of travel patterns since the start of the pandemic and when Ontario enacted lock-down orders (March 2020). It may also provide a deeper understanding of travel patterns to better prepare for any future pandemics of this kind.

The Mobility Tool can be used for:

- Planning and needs assessment: For example, the tool can be used to investigate which regions are more responsive to mobility-restriction policies;

- Monitoring of mobility changes: For example the tool can be used to compare mobility patterns between regions experiencing a significant disease outbreak, and those that are not, to better understand the factors underlying the outbreak;

- Resource allocation: For example, the tool can be used to plan for resources to provide necessary support in communities less responsive to mobility-restriction policy changes;

- Research: The tool can be used in the initial stages of hypothesis formulation. For example, to understand whether differences in mobility patterns may be correlated to the social and demographic make-up of a health unit such as income, rurality, or visible minority.

This document outlines the data sources, methods and instructions on how to use the data in the tool including how to cite the tool as well as contact information for further questions.

Data Sources

The data sources used in the creation of the Mobility Tool are:

1) Google Mobility Reports (1)
2) Government of Ontario, Ministry of Health and Long Term Care Press Releases (2)

Methods

Google started publishing Mobility Reports, and accompanying data, since the beginning of the COVID-19 pandemic in March 2020. This information is provided for worldwide regions and updated every 2-5 days. Data is compiled from Android apps, most notably the Google Maps app. There are important caveats to consider when using these data and details are found in Google Mobility Reports. For example, the data is available only from mobile devices with an Android operating system and users who have not opted out of providing location data to Google. This may not be a fully representative sample of the movements of the population in a certain region. The data provided shows a relative change to the baseline (a 5-week pre-pandemic period in January 2020) - it compares by region and day-of-the-week. This can confound mobility changes due to seasonal and population variations due to the progression of the COVID-19 pandemic. Finally, the data can be sparse for some under-populated regions and the results from those health units should be interpreted with caution.

The Mobility Tool will download the latest dataset from Google's Mobility website upon startup or when prompted by the *Force Data Refresh* button on the tool page.

We used the Ontario subset of the Canadian data file from Google Mobility Reports.
Google data for Ontario is divided into 51 regions which mostly align with Statistics Canada-defined Census Divisions, with some small exceptions (mostly where data for some Census Divisions is further split into Census Subdivisions). This Google data is reorganized by the tool into public health units (PHUs), which largely follow Census Division boundaries by averaging data in Census Subdivisions, when necessary. For example, Google provides separate mobility data for the Municipalities of Simcoe County and Muskoka District. The two sets of data are averaged to display mobility for the Simcoe-Muskoka Public Health Unit.

The dataset also includes mobility metrics for all of Ontario which can be overlaid (wide, light-grey line) on top of curves of the PHUs chosen by the user.

The data from Google is provided as a change (in percentage) from a baseline period (5 weeks in January/early February, 2020). We displayed it as a *Mobility Index* by adding 100(%) to the original data. Hence, a *Mobility Index* of 100% means no change from the baseline period; anything less than 100% means a decrease from baseline and anything greater than 100% means an increase from baseline. The mobility metrics are as defined by Google and measure differences in traffic volume from baseline in various categories of places with the exception of the *Residential* category. Google provides data in the *Residential* category which measures time spent in places categorized as residential. We reformulated the residential mobility as *Overall*

mobility (1 – residential mobility) to show the change in the amount of time spent outside of *Residential* places.

Smoothing - Overview

Smoothing is a well-established concept in statistics and it is important to understand its effects.

Data points are smoothed to improve visual aesthetics and readability. Smoothing causes the data points closely situated on the time axis to take on similar values. This results in a smoother and more readable curve and can help to discern underlying trends in mobility by hiding some random day-to-day variations.

Too much smoothing may hide systematic variability that is not purely random. It is up to the user to choose this tradeoff.

The tool provides a *Degree of Smoothness* slider, which varies between 1% and 100%. Very small smoothness values will produce lines which closely follow the actual data, but will be quite jagged and may be difficult to interpret. Large smoothness values will produce very smooth lines which may hide important short-term variations. The smoothness scale is relative to the amount of data displayed, which is the number of days controlled by the date range slider. For shorter time frames (fewer days displayed) larger values of smoothness is required to obtain the same visual effect as would be seen with a longer time frame. In such cases setting the smoothness to a very small value may fail to produce any curves.

For longer time periods (close to a year) the program will automatically choose the smoothing parameter and ignore the setting of the slider.

Smoothing can be especially misleading near the end points (i.e., the first and last couple of data points from the time period selected), thus, smoothing is not recommended when trying to discern the trend from the last few days displayed. To interpret the trend at the end points, we suggest setting the degree of smoothness to as small as possible, limiting the range of data to display, and setting the *Display Points* option to on, to display actual observed data with the curves.

Smoothing – LOcally Estimated Scatterplot Smoothing (LOESS) Procedure

For periods shorter than a year, the LOcally Estimated Scatterplot Smoothing (LOESS) procedure is used to produce smoothed curves.

Curve fitting is the process to create a curve that fits best to given data points. The LOESS procedure refits a simple linear regression at each data point using only a subset of surrounding data points. The curves are built using predictions from these regressions at each data point. Through this process, the subset of surrounding data points for each data point undergoing regression is distilled down to two data points with similar predicted values. Given the smaller

difference between the predicted values, this results in a smooth curve. The *smoothness* slider chooses the amount of data around each data point to use in the regression: large values of smoothness use more of the available data and hence produce little change in regressions, resulting in very smooth curves. Conversely, small values of smoothness use less available data, and the regression fits for the subset of surrounding points may vary as the underlying peripheral data may change significantly.

Smoothing – Generalized Additive Model (GAM)

For longer time spans beyond one year, the Generalized Additive Model smoother is used and the degree of smoothness is set automatically.

Using the Mobility Tool to Show Policy Changes

As the pandemic progressed, various policies were implemented by the Ontario provincial government and PHUs. To visualize the timing of the policy changes and the subsequent changes in mobility, the tool has an option to display *Policy Changes* lines. This option shows the major pandemic restriction changes instituted in the PHUs in the output plot.

Provincial policy changes, such as stay-at-home orders are displayed regardless of the PHU selected. For example, starting in November 2020, the province instituted a colour-coded scale to communicate the level of restrictions imposed in a given PHU (3). The tool displays the dates of Red (Control) and Grey (Lockdown) policy announcements. This data is compiled manually and updated periodically using official Press Releases from the Government of Ontario, Ministry of Health and Long Term Care. The colour-zone framework was abandoned by the province at the end of May 2021.

Weekend Effects

Certain mobility metrics, such as *Workplaces* or *Overall*, have a strong weekly cyclical component which can create confusing or misleading curves. There is an understandable variability resulting from differences in weekdays and weekend mobility which can obscure systematic trends. The relative nature of Google Mobility data can also lead to misleading trends due to differential responses to mobility restrictions on weekends over weekdays. For example, during periods of government-mandated policy restrictions, many office-based employees were able to work from home, thus substantially reducing workplace mobility on weekdays. However, that choice was not available to others, such as those working in manufacturing, retail, and other essential-services. Such essential workers also often work on weekends as well as during the week. This may show up as “high” weekend workplace mobility - showing little reduction from pre-pandemic - and when combined with effects of smoothing may underestimate the true reduction in overall workplace mobility. To mitigate the “weekend effects”, users can choose to display *Weekdays Only* in the output curve.

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