Visualizing Mobility and COVID-19

Lily Bryant, Frank Yu, James Yoo

{labryant,frankyu,yoo}@cs.ubc.ca

The University of British Columbia

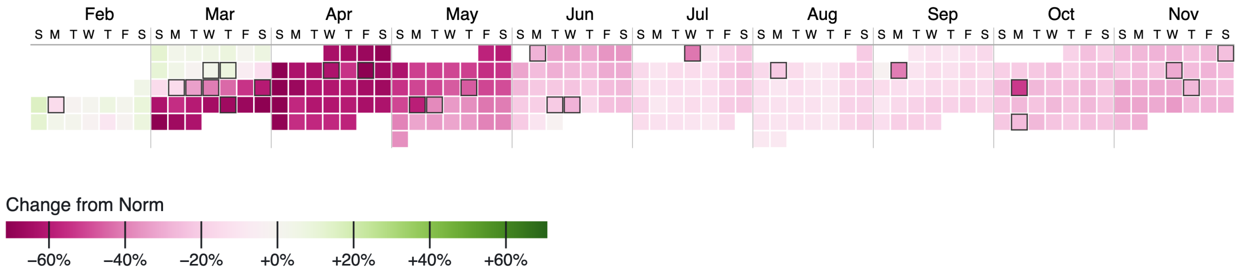

Fig. 1. A view of the calendar heatmap visualization from our interactive explainer. It visualizes the changes in mobility for the Retail & recreation category for the province of British Columbia

Abstract— We implement an interactive explainer article (`http://www.jyoo980.github.io/vis.html`) for readers with any level of expertise to perform exploratory, consumption, and analysis tasks on data describing the movement of individuals during the COVID-19 pandemic. We define our scope to be the mobility of inhabitants of Canada, with a focus on trends in British Columbia. Through the use of a calendar heatmap, choropleth maps, and a number of line chart visualizations, our article presents recent mobility data for the categories of Retail & recreation, Grocery & pharmacy, Parks, Transit, Workplaces, and Residential via a guided narrative with moderate user interaction.

Index Terms—Mobility, COVID-19, interactive explainer, interactive visualization.

1 Introduction

The COVID-19 pandemic is without a doubt the largest event in recent memory to have disrupted the lives of billions of people on a global scale. Many across the globe have changed their daily routines as a response to this event; within society, people have changed how they work, play, and otherwise spend their time. Advances in technology and the ubiquity of mobile devices have accelerated the collection of data on a massive scale, especially with respect to how the mobility of individuals has changed across the course of the pandemic.

Although the scale of mobility data collected throughout the pandemic is massive, it requires an extensive amount of pre-processing and domain-specific modelling that makes interpretation difficult for a layperson. In order to be useful, the data and related trends need to be presented in an accessible way. Tasks such as comparing the changes in mobility across regions, or observing a change in a behaviour over time during the pandemic may be of interest to a layperson and thus should be available.

We introduce an *interactive explainer* that leverages a number of visualizations to help present mobility data collected during the COVID-19 pandemic in a way that makes trends easily observable. Our interactive explainer article will be focused on visualizing changes in mobility across Canada, with a particular focus on the province of British Columbia.

2 Background

Mobility is defined as the study that describes how individual humans move within a network or system [9]. Various infection mitigation measures introduced throughout the COVID-19 pandemic have led to marked changes in the mobility of individuals in their communities. The reduction of activities in community locations that can be categorized under Retail and recreation, Grocery and pharmacy, Parks, Transit, Workplace, and Residential have been the focus of efforts to mitigate community transmission of COVID-19. Our work explores the trends in mobility across these categories.

Taking a focused approach to data from Canada, and British Columbia in particular, also affords us the option of framing our visualizations in the context of government-mandated shutdowns. A specific example could be visualizing how mobility changed with respect to the phases of British Columbia's Restart Plan [4].

2.1 Responsible COVID-19 Visualizations

Misinformation about COVID-19 is incredibly widespread. Visualizations are widely used to disseminate information that may be incorrect or even harmful. For example, data scientists and statisticians have been producing their own models and and visualizations that attempt to draw conclusions about the spread of the virus [10]. There has also been a marked focus on visualizing case numbers without providing additional context.

In creating responsible visualizations, we will not be visualizing or generating any models of how COVID-19 progresses in a region. We do not have the necessary background in epidemiology to do so, and proceeding without further domain knowledge in this space would be unethical. We will also not be focusing on the visualization of case numbers for our visualizations. Instead, our visualizations will be centered around data relating to the mobility of individuals on a regional basis.

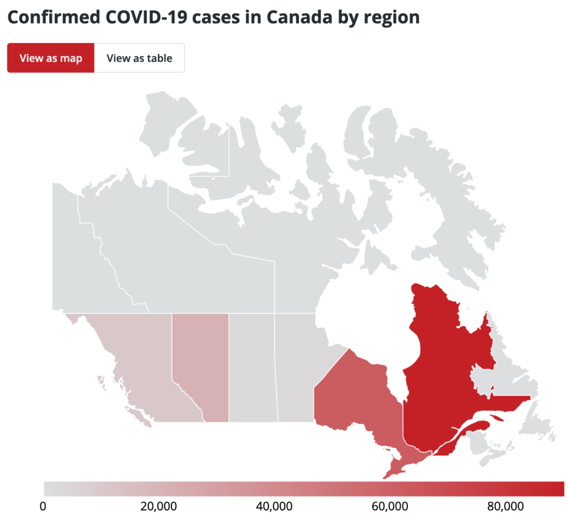

Fig. 2. A choropleth map from the CBC Coronavirus Tracker

3 Related Work

We separate the body of related work into visualizations specific to COVID-19 and visualization work orthogonal to COVID-19, and then explore the interactive explainer format as well as surprise map design idiom.

3.1 Visualization in the space of COVID-19

The explosion of public interest in the progress of the COVID-19 pandemic has led to a proliferation of information visualization work that explores data specific to the pandemic. *Fig.2* shows a choropleth map from the CBC Coronavirus Tracker [1]. The tracker exists in the form of a web page that contains a number of visualizations. It enables users to perform tasks such as viewing the number of new cases, cumulative cases, and death tolls in Canadian provinces across a range of months. In our solution, we include further interactivity to allow for more detailed investigation, an aspect which is lacking in the CBC choropleth map.

With the Google COVID-19 Community Mobility Reports [2], Google provides a web service where users are able to view mobility data for specific regions. *Fig.3* is an example of a sample PDF that users can generate. It shows a small multiple of line charts that visualize the changes from baseline mobility levels across a number of activity categories. Although the data provided is rich, there are a number of pitfalls. These visualizations do not enable a pairwise or one-to-many comparison between regions for which data was collected. There is also the added complexity of users needing to explicitly download these PDF visualizations on per-region basis. We remedy this in our solution by providing visualizations for which regional data is displayed on-demand, enabling pairwise and one-to-many comparisons without the user needing to collate an ensemble of downloaded visualizations themselves.

A work we discovered toward the end our project was the COVID-19 article and database provided by Our World in Data [11]. It includes a large number of interactive visualizations related to tracking the global progress of the pandemic, communicating community transmission mitigation measures, as well as which countries are appearing to make progress against the pandemic. The article was not focused on visualizing changes in mobility due to COVID-19 as it took a more general approach. They also primarily used three standardized design idioms to visualize their provided datasets. *Fig.4* describes a choropleth map from Our World in Data that enables users to view mobility changes across the world using the Google COVID-19 Community Mobility Reports dataset. Our interactive explainer takes an explicit focus on visualizing mobility, and limits its scope to data for Canada.

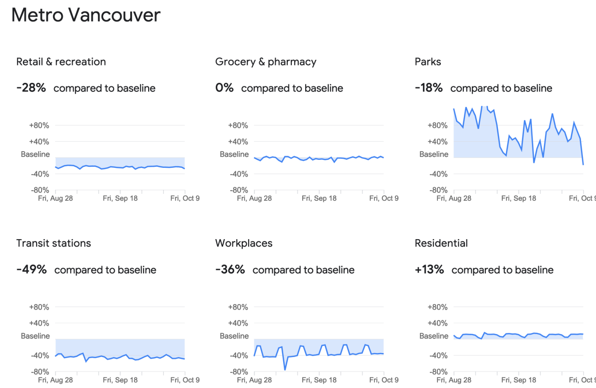

Fig. 3. A small multiple composed of line charts tracking changes in mobility for activity categories in Metro Vancouver

3.2 Visualizing Mobility & Mobile Sensing

The visualization of human mobility trends is a task that is often central to urban planning. This is especially evident in planning for infrastructure that is closely coupled with how people move and travel, such as public transportation infrastructure [5]. In this survey paper, Andrienko et al. explored how mobility data was used to inform the design of large-scale transportation systems. Many papers referenced in their survey described how visualizing mobility data is often subject to the problem of visual occlusion and detailed the difficulty of clearly visualizing large volumes of data distributed across a similarly large number of categories.

Our interactive explainer mitigates this issue by vastly pruning the visualization space of mobility data by selecting specific *categories* for which we visualize trends as opposed to showing data for a large number of locations. We also work with a smaller subset of data by pre-processing our initial dataset to only include data collected for Canada.

The concept of using mobile sensing devices to collect data for visualizing mobility is not new [12]. Smartphones and other mobile devices are pervasive enough such that they are able to provide insights into the mobility of individuals who use and interact with them. They also provide an unobtrusive way to collect data on a massive scale [12]. Using data collected from sensors embedded in mobile devices, it was possible to generate detailed line graphs of the number of vehicles that passed through an area at a certain time. This approach of visualizing data collected from mobile sensing devices is something that has yet to be explored with respect to changes in mobility during the COVID-19 pandemic.

3.3 Interactive Visualizations

The proliferation of internet access and tools for visualization such as D3 [6] has led to a democratization of creating high-quality visualization which are highly-available to a large number of people. There are an incredible number of visualizations in articles scattered throughout the internet. That said, many visualizations in these articles are static, which contradicts the expectation that many users have that the web should be dynamic and interactable. Interactive articles [8] are one solution to static web visualizations. They introduce visualizations that a user can interact with, usually accompanied by a narrative that aims to explain some of the data being visualized.

Our interactive explainer was created in the spirit of an interactive article. Visualizing mobility in the context of COVID-19 proved to be an excellent candidate for this type of article, considering the large amount of public interest and relevance. Since we aimed our visualizations to be easily interpretable by laypeople, the fact that we were able to include a narrative that helped explain our data was afforded by the interactive article format.

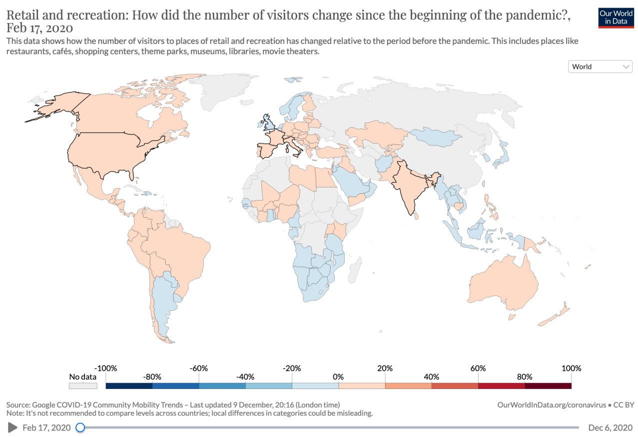

Fig. 4. A global choropleth map visualizing changes in mobility for the Retail and recreation category

3.4 Surprise Maps

While displaying raw data on a choropleth map can be helpful, it is limited when it comes to focusing attention on regions with surprising data. The *Surprise Map* [7] is a visualization for displaying geographical data that addresses the issue of surprising regional data being hidden from view. In this visualization, the authors use a new form of derived data that shows how surprising/expected a particular value is. We have adopted a surprise map in our article to visualize changes in mobility for provinces in Canada.

4 Data

Our interactive explainer article uses the COVID-19 Community Mobility Reports dataset [2] that is provided publicly by Google. It is downloaded directly as a set ofstatic CSV files. The subset of the dataset we used consists of data in the range of February 15, 2020 to December 2, 2020 and consists of 69,425 items with a total of eight attributes, six of which are the mobility categories listed below:

- Retail & recreation
- Grocery & pharmacy
- Parks
- Transit stations
- Workplaces
- Residential

A more detailed overview of our data can be seen in *Table.1*

While Google provides an incredibly detailed dataset, their privacy guarantees affect the quality of the data in some cases. In particular, some regions have no reported mobility value for certain dates. This is to ensure the anonymity of individuals in the area when there are too few visitors. Additionally, Google provides the data as a percentage change from baseline rather than as an absolute value. The baseline is static and chosen to be the median of the 5-week period from January 3, 2020 to February 6, 2020 [2]. Consequently, any normal variations, such as seasonality considerations for park attendance, are not considered in the resulting percentages.

The only pre-processing performed on the original Google dataset was the trimming of irrelevant regional data and the addition of zeroes for missing mobility data for the line chart visualizations. Otherwise, missing data is explicitly shown and labeled as such in our visualizations.

5 Task Abstraction & Usage Scenarios

We have created an article that can be viewed by a layperson. We do not assume that our intended audience has specialized knowledge in epidemiology or are intimately familiar with interpreting complex visualizations. We expect our audience to participate in tasks which resemble some form of exploratory data analysis. Some tasks may include locating which months had the greatest change in mobility in provinces across Canada, or observing how the mobility associated with an activity changed over time.

The interactive explainer format is particularly well-suited for our audience for a number of reasons. They enable the presentation of data with explicit explanations that may guide and help the audience in understanding it, even if they are not domain-experts. Additionally, they enable the inclusion of interactive diagrams which allow the audience to explore the data in the context of the explanations provided in the article.

In 5.1, we describe a use-case in which users *consume* data presented in way that describes changes in mobility from a bird's-eye view for the whole of Canada; in 5.2, we discuss a use-case in which users filter specific regions for which to view mobility data, and are able to vary the amount of data displayed with respect to time; in 5.3, we detail a use-case where users make direct comparisons between the provincial and national level; and, in 5.4, we describe a use-case where users compare overall data trends with outliers and determine their potential cause based on contextual information. Finally, in 5.5, we present our last anticipated use-case where users may want to know whether the observed mobility in a province or territory is above or below expectation.

5.1 Comparing Geographical Data by Region

We anticipate that one use-case that users may engage in is observing the differences in mobility between different regions of Canada. This would fall into the task abstraction of users that want to *consume* data. For this task, we hypothesize that users will want to see how each category of mobility is affected in different regions and if there are any regional trends. This usage scenario is mostly supported in the visualization we see in *Fig.2*, though with different data. However, we also want the user to be able to select the data they want to have visualized which is not featured in *Fig.2*.

5.2 Comparing Trends over Time

A use-case that we have considered for users of our interactive explainer is comparing trends in regions over time. For example, a user in one province may want to see how mobility has changed relative to neighbouring provinces. Although this task appears similar to the one described in 5.1, we specify that users could want to engage in observing how the data changes with respect to time. This would fit into the task abstraction of users who wish to *consume* data that has already been processed by a tool. We can anticipate that this is a task that users may use to discover what effects their changes in mobility, relative to other regions, have had on the incidence of cases in their region. This usage scenario is currently not supported by the Google COVID-19 Mobility Reports (*Fig.3*), as it is limited to displaying data for only one region at a time.

5.3 Comparing Provincial versus National Trends

In a similar vein to both 5.1 and 5.2, users may also want to make a comparison between provincial values for British Columbia with averaged totals for Canada overall over time. Users could *consume* filtered data for both area selections and make inferences about the differences in mobility between regions. This may be of particular interest to users who have knowledge of COVID-19 case numbers or varied quarantine measures and wish to evaluate their impact. This task is not directly supported in either the Google COVID-19 Mobility Report small multiples (*Fig.3*) or a simple choropleth design such as *Fig.2* due to the lack of data aggregation.

5.4 Comparing Outliers against general Trends

The COVID-19 Community Mobility Report dataset does not follow smooth trends due to a significant number of outlier data points, including holidays; cyclical behaviours in the general population such as typical work weeks; and the effects of Google's data collection methods. Therefore, we anticipate users will wish to *identify* outliers in the data and determine the causes of specific spikes and troughs to add context. Because there are a substantial number of factors that could culminate

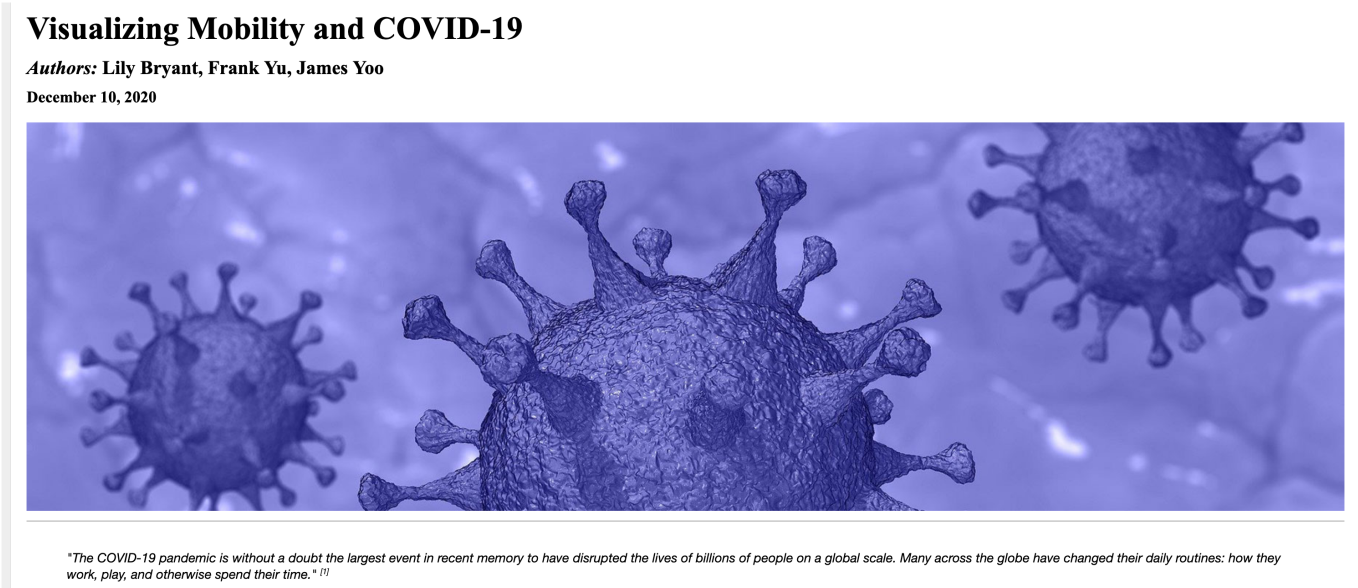

Fig. 5. The header graphic for the interactive explainer article *Visualizing Mobility and COVID-19*

in an outlier, we expect that users will want to be provided contextual information rather than needing to rely on their external knowledge. From an ethical standpoint, users should also be alerted when information is missing so they do not make unsubstantiated assumptions.

5.5 Comparing Expected against Observed Mobility

While the Google Community Mobility Dataset already normalizes the mobility for each category to show if it is higher or lower than the baseline, it does not explain whether the observed data is above or below expectation. We believe that this is a very important usage case for those who wish to use our visualization to learn about the changes in mobility. To address this limitation of the dataset, we derive a signed surprise based on the methods and similar models proposed by [7]. This derived data shows whether or not an observed mobility on a specific date is above or below expectation, given the mobility that is observed in other provinces and a variety of handcrafted models and priors. With this new derived data, we can now explicitly show users if the mobility for a given category is considered surprising on some chosen date.

6 Solution

We implemented an interactive explainer article with seven embedded visualizations (teaser in *Fig. 5*). Our explainer begins with an explanation of how the COVID-19 pandemic has led to a number of societal shifts, including substantial changes in mobility. We then present a choropleth map that gives a whole-country view of changes in mobility for a number of categories in Canada. This is immediately followed by a signed surprise map. The explainer then continues with a number of line graphs that enable the reader to visualize inter-regional mobility; a calendar heat map which helps to draw attention to specific dates for which mobility has notably changed as well as make comparisons between trends in British Columbia and Canada overall; and concludes with a visualization that enables an intra-province view of deviations in mobility.

6.1 Choropleth & Surprise Maps

To address the usage scenarios presented in 5.1 and 5.5, we present a joint visualization of a choropleth map and surprise map, shown in *Fig. 7*. We complement the choropleth map with a corresponding surprise map to address some of the inherent limitations of choropleth maps that we described in 6.1. For the choropleth map, we simply display the unprocessed Google Mobility Data for each province on a specific date. However, in order to generate the complementary surprise map, we follow the procedure of [7]. To generate the signed surprise, we first define two models that we believe should describe the observed data; to do so, we make similar assumptions to the example for Canadian mischief that [7] provide. We assume the following two models:

- Model 1: the variation in every mobility category is inversely proportional to provincial/territorial population
- Model 2: if there are no geographical factors that affect mobility, of any category, the observed mobility for each province should be equal to each other

We assume a Gaussian distribution for both models. For Model 1, we center the Gaussian distribution at zero and, for Model 2, we center it at the mean of the daily categorical mobility. We also include a multiplier for the variance for each mobility category which is calculated based on the range of observed values. This multiplier is used when calculating the likelihood for Model 1. We assume a naive prior probability of 50% for each of these models. We report the values as a signed surprise rather than an absolute surprise so that users can see whether the observed mobility on a certain day is above or below expectation.

We provide the same interactivity for both visualizations containing these models. This includes a scrubber to select an individual date, a play button to automate date scrubbing, and a tooltip hover feature so users can inspect either the signed surprise or mobility for a province or territory. We also include a divergent color scale for both visualizations that change depending on which mobility category is selected.

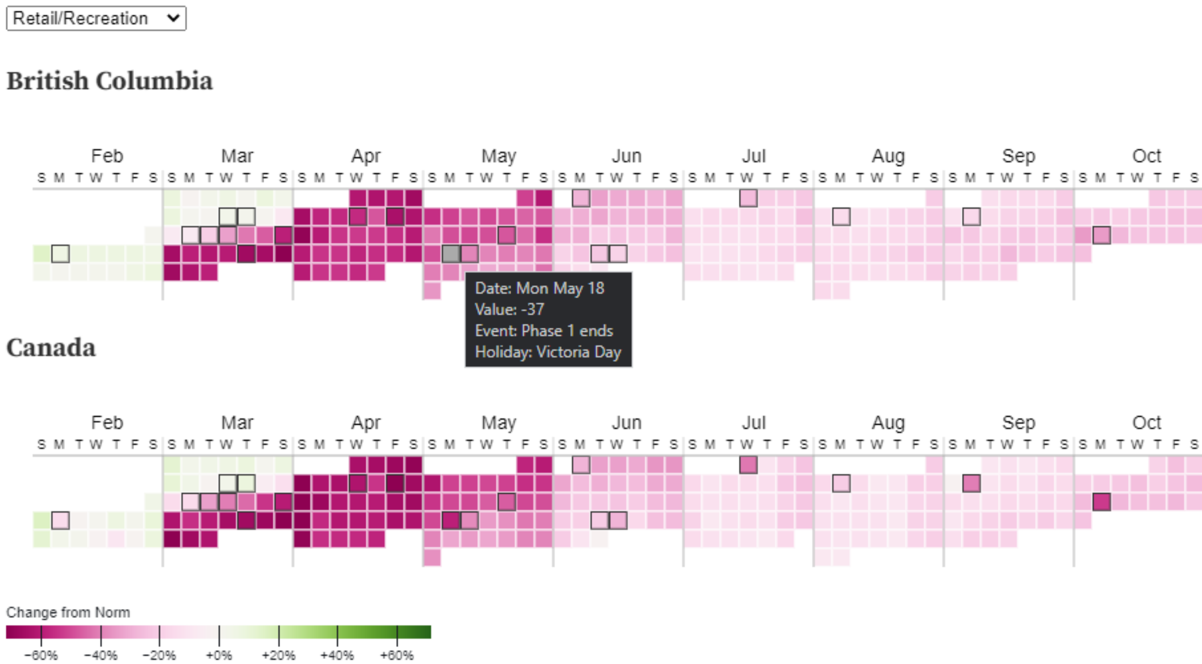

Fig. 6. Calendar heatmap visualization showing Retail & recreation category. Highlighted in the center of the image is a tooltip hover feature which includes specific date information.

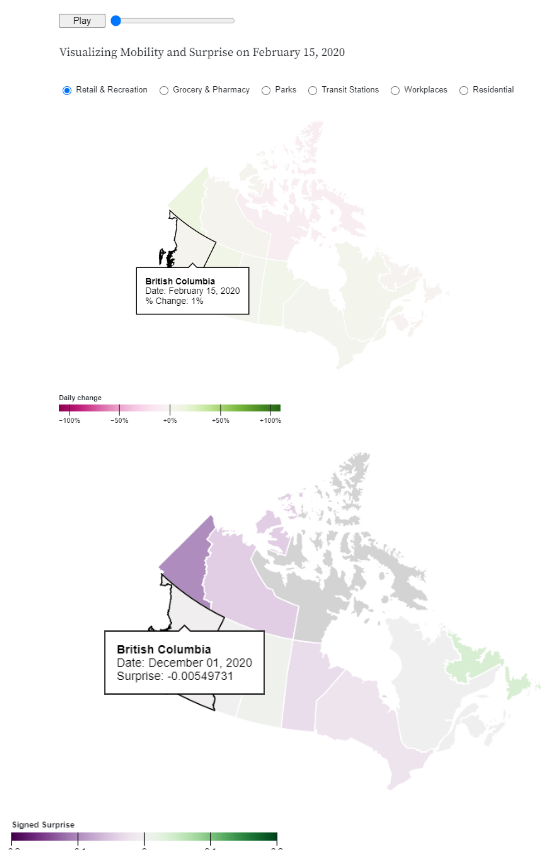

Fig. 7. Canadian choropleth and surprise map showing mobility and signed surprise on December 1, 2020 for the Retail and Recreation category. Shown in each map is an example of the tooltip hover feature as well as the scrubber and radio button selectors used to choose the date and mobility category, respectively.

6.2 Provincial/National Comparison Calendar Heatmap

The calendar heatmap visualization, shown in *Fig. 6*, provides a simple solution for the usage cases described in 5.3 and 5.4. This design is used in our interactive explainer article for the categories of Parks, Retail & recreation, and Grocery & pharmacy. We include shaded cells for every date available in the dataset and group them by calendar month to provide an intuitive way to view changes in mobility over the course of the COVID-19 pandemic. The dynamic legend at the bottom of the visualization uses a diverging colour palette to distinguish between positive and negative change from baseline for a given category. Additionally, we separate the data for British Columbia from the averaged values for Canada to allow the user to make comparisons between general trends in both regions.

Initially, we planned to split each date cell so that it contained colour-coded values for both British Columbia and Canada, but decided against it due to issues of visual complexity. Although this results in some repeated information and increased comparison distance, we believe that the new design is sufficient for the user to make inferences about general trends in the data.

Our second use case, which allows users to identify outliers and compare them to broader patterns, is integrated through outlined important dates and a hover tooltip feature. Date cells that fall on provincial holidays or correspond to changes in provincial lockdown measures in British Columbia are highlighted. Further information on the event as well as the concrete mobility category value is available by hovering over the given cell. The familiar shape of a calendar also allows users to easily find other repetitive patterns, such as consistent variation between weekday and weekend.

6.3 Mobility Line Graphs

To address the use-case described in 5.3, we introduce a number of line graphs. These inter-regional mobility line graphs, shown in *Fig. 8*, enable users to compare trends in mobility across Canadian provinces and territories. It uses a lines as a mark for a selected province or territory, and uses colour as a channel to aid in delineating between them. This visualization is repeated for the mobility categories of transportation, workplace, and residential. To enable a user to compare mobility trends across the categories provided by the Google COVID-

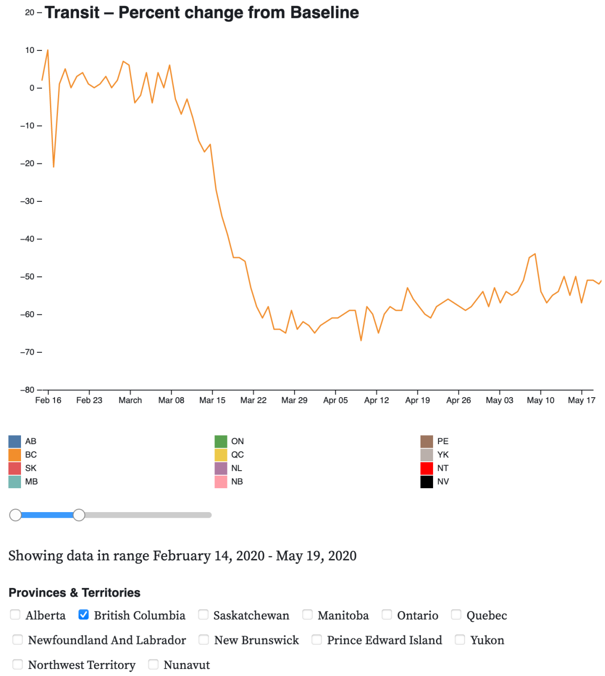

Fig. 8. An inter-regional mobility line graph for the Transit category

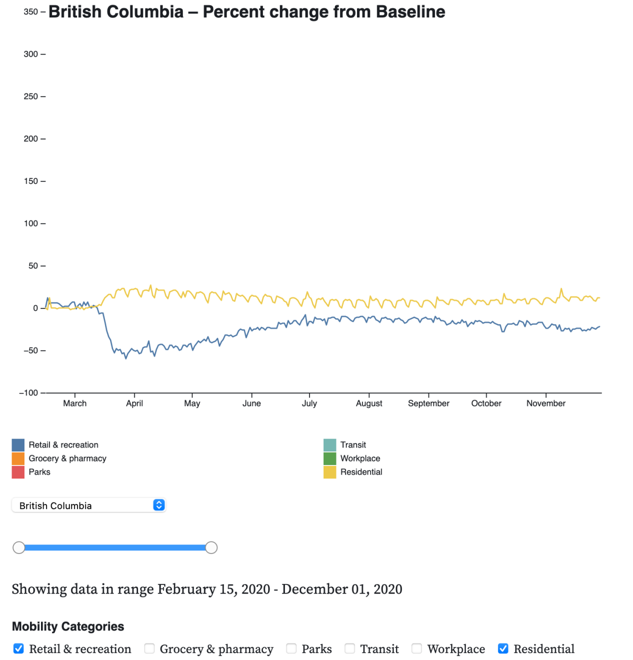

Fig. 9. An intra-regional mobility line graph selected for the province of British Columbia

19 Community Mobility Report dataset, we have also introduced an intra-regional mobility line graph (*Fig. 9*). This visualization enables a user to engage in tasks such as comparing trends for different mobility categories while holding a region of interest fixed. In the intra-regional mobility line graphs, each line is a mark which represents a selected mobility category

For both the inter-regional and intra-regional mobility line graphs, we enable users to filter through the data by providing a range selector for the date. This selector affords a higher level of data granularity in the line graphs as users may choose to zoom in on a smaller range of dates for which they wish to analyze the given data. We also provide a tooltip that users may use to precisely inspect mobility data when one mark is displayed.

7 Implementation

We used Observable Notebooks [3], a web service for creating interactive visualizations with D3 and a domain-specific subset of JavaScript, to prototype our initial set of visualizations. We iteratively refined them over time, eventually arriving at a finalized set of visualizations that we exported and embedded into a custom web page built using HTML and CSS. *Table.2* provides a detailed timeline describing the tasks that were required to develop our interactive explainer.

8 Discussion & Future Work

We discuss the strengths, technical challenges, and limitations associated with our end-product. We conclude with some considerations for future work.

8.1 Strengths

A strength of our visualizations lies in the presentation format. Presenting our visualizations next to explanatory text enables users to directly engage with the visualization, make their own inferences about the data, and verify their understanding. This could be especially helpful for individuals who are not domain-knowledge experts in mobility, COVID-19, or information visualization. Our explainer article could also be helpful to individuals who wish to obtain information about COVID-19-related mobility at a quick glance, as they could obtain this information directly via the text as opposed to spending time interpreting our visualizations. Alternatively, users with more experience could spend more time on the visualizations.

Because we use a variety of custom visualization types, we were able to tailor each component to the article story line. A single, more robust visualization may not afford the flexibility needed to fully satisfy some of our use cases. Additionally, the separation lends itself well to simpler visualizations which are more likely to be easily understandable for the layperson.

By limiting the scope of data we visualize to Canada, with a particular focus on the province of British Columbia, we are able to create a focused set of visualizations that do not overwhelm the user with large amounts of data that they would be responsible for interacting with.

Finally, by stepping away from making any strong epidemiological claims in our explainer article, such as making inferences about the future of COVID-19, and allowing the reader to come to their own conclusions, we mitigate some of the dangers associated with presenting models on pandemic data. From an ethical standpoint, we do not want to present claims we are unqualified to make. In our opinion, we succeeded in making the article sufficiently exploratory without making these strong claims; a statement which is supported by our decision to design visualizations that do not work on heavily-processed or severely-limited subsets of data.

8.2 Technical Challenges

While the Observable platform provided a number of rich templates for rapid prototyping, it was not without its pitfalls. It used a subset of JavaScript for which traditional JavaScript development experience did not immediately translate into. The fact that most code was required to be written in separate cells meant that obtaining a whole-program view of visualization code was difficult. Direct debugging of code was also not supported by the platform. This meant that when bugs arose, development efforts were hampered as we would often have to resort to changing small sections of code at a time and re-loading the cell or notebook.

8.3 Limitations & Lessons Learned

While we have produced numerous iterations of our visualizations that we present in our interactive explainer, there are still some limitations that are inherent to the visualization techniques we chose.

A weakness of our line graph visualizations is how they fail to scale with a large number of selected marks. It was the case that most provinces followed a similar trend for mobility changes across categories, which meant that there was often visual occlusion between marks when, for example, changes in transit mobility are being visualized for the provinces of British Columbia. A possible workaround for this limitation is to enable users to zoom into a more detailed view with a more granular scale. The data for most mobility categories and provinces being similar in most cases limits the efficacy to which a line graph is able to clearly delineate between marks.

All of our visualizations rely on colour to distinguish separate marks and data values. In particular, the choropleth maps and calendar heatmap use shade differences to disambiguate percent change from baseline for the mobility categories. This is known to be somewhat challenging for users, especially when values are numerically similar or further apart on the screen. Although there are other options to avoid this issue, such as using pattern, we decided that the alternatives would only increase visual complexity, an already limited resource.

Furthermore, because we use a standard map visualization to display both the daily categorical mobility and the signed surprise, we run into the limitation that small regions (like Prince Edward Island in our visualization) are often hard to see. This means that users may find it difficult to observe particular values for a region or even distinguish it from neighbouring regions. A possible workaround for this limitation could be the use of a fisheye feature to emphasize small regions on the map; although, this would become cluttered if there were many small regions. If it would come to this point, it may be beneficial to include a zoom feature in the visualization.

8.4 Future Work

There are a variety of tasks that we believe would improve our visualizations, our article, or the study of mobility during COVID-19 in general, which we leave for future work. We discuss a selected number of them here in no particular order of their priority.

Accessibility is pertinent to visualizations that work for everyone. Introducing a color palette across our visualizations that takes color deficiency into consideration would be a definite step toward improving the accessibility of our article. This could be implemented by having all colors used in our visualizations be color deficiency friendly by default, or by creating color deficiency friendly versions of our visualizations that users are able to select.

We currently support tooltips for our mobility line graphs when only one province or territory is selected. This is to mitigate visual occlusion. Enabling support for tooltips regardless of the number of selected marks would enable users to view mobility changes with a higher level of precision than what is currently afforded by our line graphs. More work is required to enable this in a way that does not cause occlusion to occur for users.

For our surprise map, we use two very simplistic models to derive the signed surprise data. While the results currently appear fine, there is room to improve the models and priors that we currently assume or even include additional models. One possible avenue for a new model could be one that takes the day of the week on which the mobility is observed into account. Doing so could account for a potential increase in variance for certain mobility categories that occur on weekends. We could also work on improving our map visualizations such that the scrubber is not subject to performance issues. As it is currently implemented, the re-rendering of maps currently lags behind the rate at which the scrubber is able to be manipulated by a user.

Since the COVID-19 pandemic is ongoing, we could pursue the automation of our data sourcing and processing. This would ensure that our visualizations remain up-to-date without human intervention. Currently, Google does not expose an API for retrieving the COVID-19 Community Mobility Report data, so this would be a substantial task. Additionally, as discussed in 4, Google fixes their baseline value to a particular date range and does not provide access to the raw data. This would also need to be resolved to provide more accurate trend analysis; however, there are a limited number of solutions that preserve anonymity for the data subjects.

Although Observable was a helpful tool for developing initial designs and allowed us to easily embed the final visualizations into the article as HTML iFrames, future iterations of the interactive explainer should move the D3 code to a standard JavaScript file. Some of our finalized designs struggle with performance issues that are tied to Observable's cell structure which prints out parsed output and includes other performance overhead. The web tool also requires payment for collaborative workflows and other advanced features.

9 Conclusion

We introduce an interactive explainer with a number of embedded visualizations. Our choropleth map of Canada enables a whole-country view of changes in Canadian mobility, while our surprise map explores the extent to which a given change in mobility is expected or unexpected. Exploring changes in mobility for specific dates, such as holidays or the days on which provincial health measures were introduced by the British Columbian government, is supported by our calendar heatmap. Viewing trends over time for mobility categories across Canadian provinces and territories is enabled by our inter-regional mobility line graphs, and a within-regional view of mobility trends can be explored with our intra-regional mobility line graphs. Coupled with a text narrative, our visualizations provide an interactive artifact that helps to explain how mobility has changed for Canada during the course of the COVID-19 pandemic and is accessible to domain-experts and laypeople alike.

10 Acknowledgements

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Attribute Name	Type	Range/Unique Values	Description
Province	Categorical	13	Canadian provinces and territories
Date	Sequential	2020-02-14 to 2020-12-01	Date range for which mobility data was collected
Retail and Recreation Percent Change from Baseline	Quantitative	-90.0 - 109.0	The percent change from baseline levels for retail and recreation
Grocery and Pharmacy Percent Change from Baseline	Quantitative	-59.0 - 114.0	The percent change from baseline levels for grocery and pharmacy
Parks Percent Change from Baseline	Quantitative	-79.0 - 578.0	The percent change from baseline levels for parks
Transit stations Percent Change from Baseline	Quantitative	-80.0 - 39.0	The percent change from baseline levels for Transit stations
Workplace Percent Change from Baseline	Quantitative	-81.0 - 16.0	The percent change from baseline levels for workplaces
Residential Percent Change from Baseline	Quantitative	-5.0 - 34.0	The percent change from baseline levels for residential

Table 1. An overview of the Google COVID-19 Community Mobility Report Dataset

Estimated Date of Completion	Actual Date of Completion	Tasks	Estimated Hours (Total/Per person)	Actual Hours		
				James	Lily	Frank
October 21	October 21	Write project proposal and divide tasks	18/6	6	6	6
November 1	November 1	Learn Observable + D3 + JavaScript	*New*	4	2	6
November 10	November 13	Implement first draft of article visualizations and associated models	15/5	8	8	13
November 17	December 1	Write first draft of interactive explainer article content	9/3	3	3	3
December 3	December 3	Update paper content and visualizations to include feedback	9/3	5	5	5
December 10	December 10	Implement final article visualizations	15/5	9	9	12
		Write final draft of interactive explainer article content	9/3	4	3	3
		Design website for interactive explainer	*New*	2	5	1
December 14	December 14	Create content for final presentation, prepare talking points, and record	9/3	10	9	6
		Update paper to include final designs and feedback	12/4	6	6	6
-	-	Synchronous Meetings	*New*	10	10	10
-	-	Asynchronous Communication	*New*	8	8	8

Table 2. Work breakdown showing initial expected hours and actual individual hours put into each task.