Examining changes in bikeshare use in Edinburgh during the COVID-19 Pandemic

1 Overview

The COVID-19 pandemic has brought changes to many aspects of our lives, including our use of transportation and or participation in leisure activities. This report examines the impact of the COVID-19 pandemic on use of bikesharing – specif cally to determine if changes in use of the Edinburgh Cycle Hire bikesharing scheme have occurred during the COVID-19 pandemic.

To determine if any such changes had taken place, visualisations of the number of rides by month, duration of hires, and time of day of hires were created for both prepandemic and pandemic periods. The signif cance of changes in use of the scheme was determined by computing p-values for number of riders, using the poisson e-test used to compare number of hires from before and during the pandemic.

The visualisations created and statistical technique used indicated that there was a signif cant difference in the usage of the cycle hire scheme between the pandemic and prepandemic years. Differences were observed in the number of trips, duration of trips, and time of day of trips. Further research could examine changes in the origins of rides or impact of socioeconomics on rides.

2 Introduction

Context and motivation   Edinburgh Cycle Hire (branded as "Just Eat Cycles") is a bike-sharing scheme in the city of Edinburgh, introduced in 2018. Bikes are available for hire at 96 stations located throughout the city, with a f at rate for rides under 1 hour in duration and a per-minute tariff afterwards.

The COVID-19 pandemic is an international outbreak of COVID-19, a disease caused by the novel coronavirus SARS-CoV-2. Scotland recorded its f rst case of the novel coronavirus on 1st March 2020. Mitigations taken by the Scottish Government to lower the spread of COVID-19 include a stay-at-home order at various times since 23rd March 2020, the closure of many businesses and off ces, discouraging the use of public transport, and enforcement of social distancing[1].

During the COVID-19 pandemic, use of public transport decreased, with bus use declining to around 10% of prepandemic levels, and rail use to less than 5% of normal[2]. Mobility data showed a decline in movement and activity to 37% of normal levels[3]. At the same time, many councils across the U.K., including Edinburgh[4], built additional bicycle infrastructure, and the number of bikes sold in the UK increased by 45% year on year[5]. This study will examine usership information made publicly available by Edinburgh Cycle Hire to determine if this increased interest in cycling translated to increased use of Edinburgh Cycle Hire.

Previous work   Padmanabhan et al.[6] demonstrated a reduction in use of rideshare during the initial wave of COVID-19 in the American cities of New York, Boston, and Chicago. However, they also reported an increase in average trip duration.

Hu et al.[7] reported that the proportion of bikeshare commuting trips made in Chicago was substantially lower during the pandemic. They also reported that areas with higher White and Asian populations, and areas with higher incomes, had higher overall use of bikeshares, but also a greater decrease in use during the pandemic.

Objectives   The objectives of this project is to determine what changes in use of the Edinburgh Cycle Hire scheme, if any, took place as a result of the COVID-19 pandemic. This report will examine the number of trips made, the duration of these trips, and the time of day at which trips were taken, to determine if any of these were changed by the COVID-19 pandemic. Both visual and statistical analyses will be carried out.

3   Data

Data provenance   Data was obtained from the Edinburgh Cycle Hire website[8] – the data is supplied by the company themselves. The data was downloaded to a local system for initial exploration, then uploaded to notable for processing. The data was provided under the Open Government License v3.0[9] – despite being operated by Serco and branded by Just Eat, the service is ran on behalf of Transport for Edinburgh, an arm of Edinburgh Council. This license allows for (among other rights) the ability to copy, publish, adapt, and exploit the information for non-commercial purposes, provided the source of data and license are made accessible. Since these conditions have been met, it is possible to use the data for this project.

Data description   Data was formatted as .csv files, with one file containing records for all of the rides made during a calendar month. Data was used for every month from January 2019 to February 2021. This encompassed a total of 357,877 separate rides.

The following variables were used in the analysis:

- started_at and ended_ at are timestamps containing the year, month, day, hour, minute, second, and timezone that a ride started or ended at respectively.

- Duration is an integer representing the number of seconds between the start and end of a ride.

The remaining variables in the data, relating to the start and end stations, were not used in the analysis. Edinburgh Cycle Hire give descriptions of these variables on their website[8].

Data processing   Data from the monthly files provided by Edinburgh Cycle Hire was used to construct dataframes for an entire year of rides. Separate dataframes were made for calendar years (2019, 2020) and for a pandemic year (Mar 20 – Feb 21) and prepandemic year (Mar 19 – Feb 20). The "started_at" and "ended_at" variables were converted from timestamps to python datetime objects to aid visualisation by date and time. The time of day at which rides took place was derived from the processed 'started_at' variable. The number of rides in each month was derived from the number of lines in each file once loaded as a dataframe (as each file contained a calendar month of data). The proportion of rides by time of day was derived by converting "started_at" into an Hour integer, and counting the occurrences in each hour, before dividing by the total number of rides.
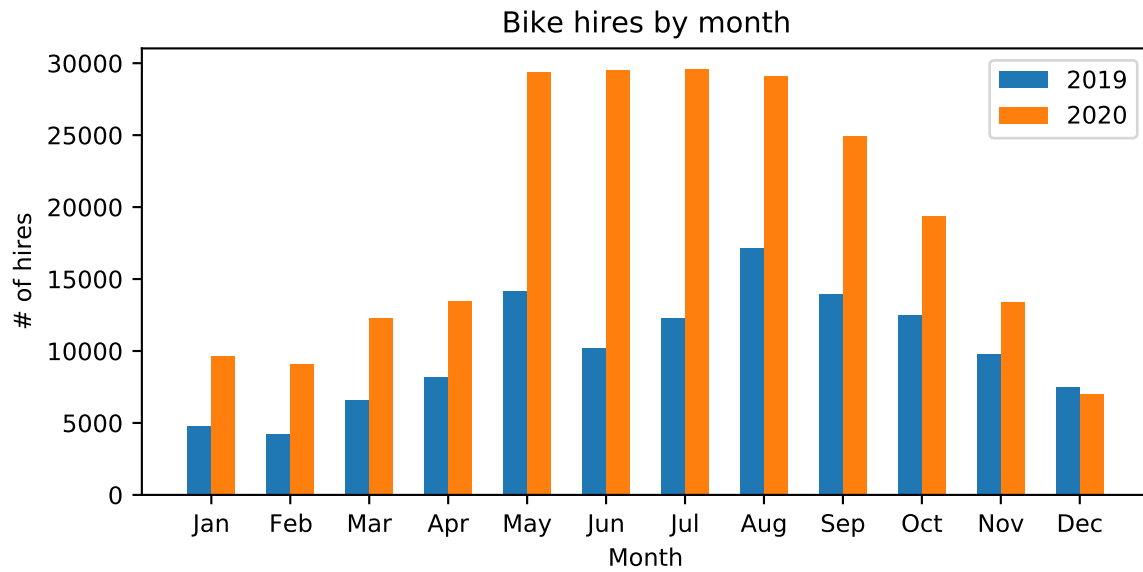
4   Exploration and analysis

Visualisations

Bike hires by month

Figure 1: Comparison of raw number of hires per month in 2019 and 2020.
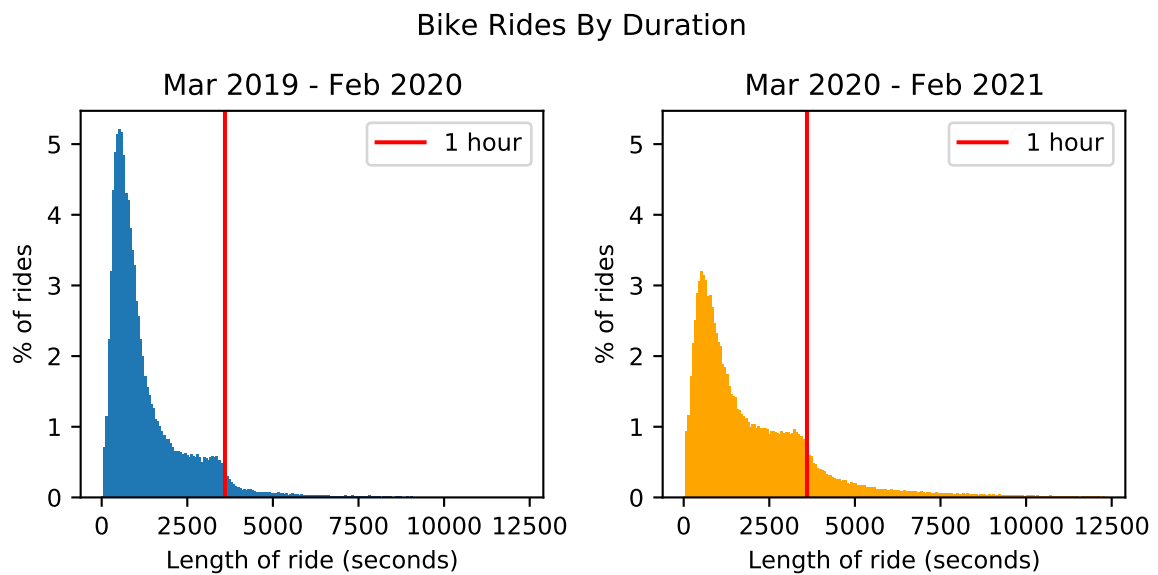
Bike Rides By Duration

Figure 2: Comparison of ride lengths between prepandemic and pandemic years. The vertical red line represents 1 hour, after which users are charged per minute.
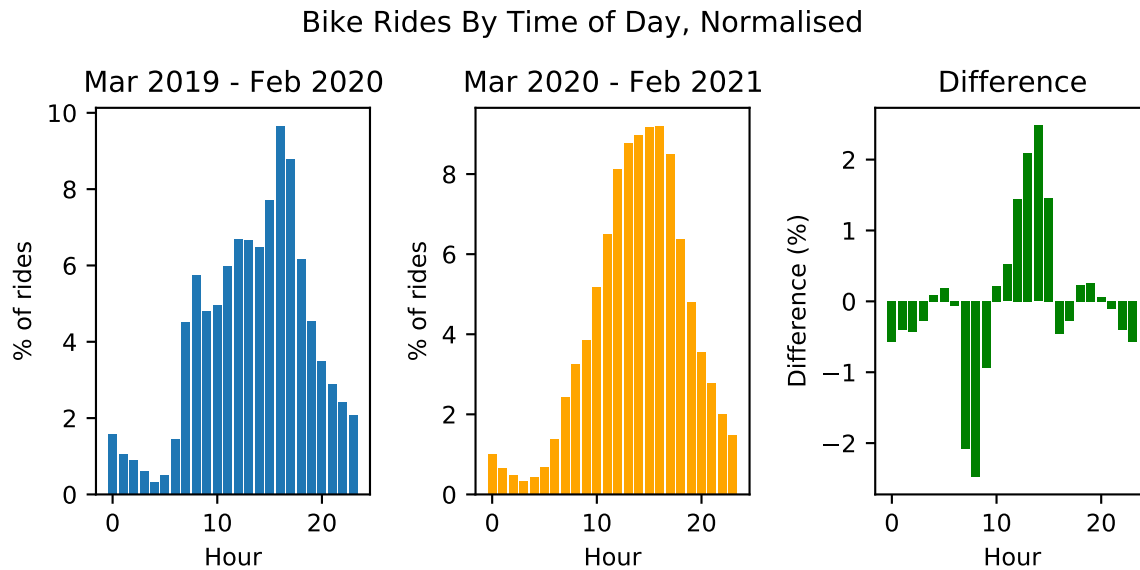
Figure 3: Comparison of rides between prepandemic and pandemic years by time of day.

Interpretation of the results Figure 1 shows that the number of rides made in 2020 was higher in every month except December. There was a particularly marked increase from April to May. The increased number of rides can be contextualised by the increase in the use of bikes overall during the pandemic - the Bicycle Association found that bike sales increased by 45% compared to the previous year[5]. It is of interest that the number of hires was nevertheless increased in January and February 2020 compared to the year prior, before any widespread restrictions were in place. This suggests that there are other confounding variables impacting the number of hires made.

Figure 2 shows that that there was an increased proportion of longer rides. The increased duration of rides could be interpreted in an increase in use of the system for leisure rather than transportation. Since many people were working from home and large events were cancelled, there were fewer potential reasons to use the system for transportation. In addition, a reduction in traffic levels of 60-80%[10] could have encouraged people afraid of cycling on busy roads to try cycling once roads became quieter.

Figure 3 shows that the proportion of rides during the morning commuter peak decreased notably. This is likely an effect of people working from home – with fewer people going into their workplace, a lower proportion rides were made at this time. A reciprocal increase in the proportion of rides made near midday and in the early afternoon can be observed. This could be theorised as an increase in the number of rides taken for leisure – with work from home resulting in more flexible schedules for some, these people would consequently be able to take time off during the middle of the day, and go cycling then.

Application of statistical method(s) The number of hires in a month was likened to a poisson process approximating a normal distribution. With this assumption, the number of rides in a month is taken to be the mean ($\bar{x}$) of a normal distribution with standard deviation $\sqrt{x}$. The poisson e-test for comparing the means of poisson distributions was used. This test returns a probability that the mean of one distribution (or a less likely value) could be produced by the probability distribution of the other, once the means have been normalised for the difference in the sample size that they were taken from. This is in effect a p-value of the null hypothesis that the two means belong to the same probability distribution. An in-depth explanation of the e-test can be found in Krishnamoorthi & Thomson[11]. The commonly used value of ($p < 0.05$) was used to determine statistical significance.

The number of hires in each calendar month of 2019 was compared to the number of hires in the same calendar month in 2020. Hires were compared in both absolute and relative terms.

Table 1: P-values generated by application of the poisson e-test to calendar months of 2019 and 2020.

Comparison	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
# Hires	0	0	0	0	0	0	0	0	0	0	0	0
Adjusted # Hires	0	0	0.241	0	0	0	0	0	0	0	0	0

Interpretation of the findings   Table 1 shows that when comparing the raw number of rides, every single month returned a p-value of 0, both demonstrating statistical significance and indicating that the null hypothesis that the number of hires in months of 2019 and 2020 were generated by the same distribution was completely implausible for the data. When the number of rides was normalised, thus comparing the proportion of rides that took place in each month, 11 out of 12 months displayed statistical significance. Assuming that it is reasonable to model the number of hires in a month as a poisson process approximating a normal distribution, this demonstrates that the number of hires was markedly different from before and during the pandemic, as was the proportion of rides that took place in each month.

5   Discussion and conclusions

Summary of findings   Overall, use of the cycle hire scheme increased during lockdown, with more than twice as many rides taking place during some months of 2020 than the previous year. The average length of ride was increased, perhaps suggesting increased use of the cycle hire scheme for leisure rather than transportation. The time of day that rides took place at also changed, with markedly fewer rides at the morning commuter peak. Changes in the number and proportion of hires, compared to the same months one year earlier, were found to be highly statistically significant.

Evaluation of own work: strengths and limitations   One strength is that the visualisations created clearly show changes in bikeshare use between pandemic and prepandemic. The graphs produced are straightforward to read and the data strongly speaks for itself. Another strength is that the statistical test used supports the visualisations – the poisson e-test gave highly significant results, suggesting that hiring patterns were different before the pandemic and during it, giving statistical support to the apparent effects observed with the visualisations.

One weakness is that only one statistical test was used, and only on one attribute of the data. Additional techniques such as linear regression could have been employed but were not. Another weakness is that it may not be appropriate to model the number of hires in a month as a poisson process approximating a normal distribution. This assumption may lead to standard deviations for monthly hires that are too small, and thus give artificially low probabilities that the means given were belong to the same probability curve, thus wrongly rejecting the null hypothesis. This would be a type I error. However since data does not exist for full years prior to 2019, the accuracy of the standard deviations used cannot be compared to real data to determine if the assumption made was accurate. Other confounding variables were not considered, such as the weather – the Met Office reported that Spring 2020 was the sunniest on record in Scotland[12], which could have had a profound impact on bikeshare usage and cycling in general.

Comparison with any other related work   Padmanabhan et al[6] found that lockdown decreased bikeshare usage in 3 American cities, whereas this research found that bikeshare use in Edinburgh increased during the pandemic. The findings do however concur with Padmanabhan et al on the duration of rides – both their research and that done here found that the duration of trips increased.

Hu et al[7] found that fewer commuting trips were made on the Chicago bikeshare system during the pandemic. Research done here demonstrates a relative fall in the number of trips made at the morning commuter peak (7am – 9am), concurring with the findings of Hu et al.

Improvements and extensions The effect of the pandemic on where bikeshare was used was not considered. One potential improvement is to measure changes in popularity of particular bikeshare stations and their environments, which could lead to interesting qualitative analysis if, for example, there was a particularly pronounced increase in hiring at beachside locations.

Hu et al found that there was a greater decrease in bikeshare use in whiter and wealthier areas – finding that changes in use varied with socioeconomics. This could be determined by incorporating data from SIMD[13] into the analysis. For example, a regression model of the change in hires at stations and the socioeconomics of the SIMD zone that the station is in could be done.

A comparison to other cities in Scotland or the U.K could be done. Since Edinburgh Cycle Hire is a relatively new scheme, it is entirely possible that an increase in coverage or awareness could be in part driving some of the changes seen. The cycle hire scheme in London has been operating since 2010[14], so usage of that scheme should be less driven by any start-up effect.

References

[1] Scottish Parliament Information Centre. Timeline of coronavirus (covid-19) in scotland. *The Scottish Parliament*, 19 March 2021. `https://spice-spotlight.scot/2021/03/19/timeline-of-coronavirus-covid-19-in-scotland/` Retrieved on 12 April 2021.

[2] Prime Minister's Office, 10 Downing Street. Slides and datasets to accompany coronavirus press conference. *HM Government*, 24 April 2020. `https://www.gov.uk/government/publications/slides-and-datasets-to-accompany-coronavirus-press-conference-24-april-2020` Retrieved on 12 April 2021.

[3] Benjamin Jeffrey, Caroline E Walters, Kylie E C Ainslie, Oliver Eales, Constanze Ciavarella, Sangeeta Bhatia, Sarah Hayes, Marc Baguelin, Adhiratha Boonyasiri, Nicholas F. Brazeau, Gina Cuomo-Dannenburg, Richard G FitzJohn, Katy Gaythorpe, William Green, Natsuko Imai, Thomas A Mellan, Swapnil Mishra, Pierre Nouvellet, H Juliette T Unwin, Robert Verity, Michaela Vollmer, Charles Whittaker, Neil Ferguson, Christl A. Donnelly, and Steven Riley. Report 24 - anonymised & aggregated crowd level mobility data from mobile phones suggests initial compliance with covid19 social distancing interventions was high & geographically consistent across uk. *MRC Centre for Global Infectious Disease Analysis, Imperial College London*, 29 May 2020. `https://www.imperial.ac.uk/mrc-global-infectious-disease-analysis/covid-19/report-24-uk-mobility/` Retrieved on 12 April 2021.

[4] The City Of Edinburgh Council. Spaces for people - temporary changes in place. 2020. `https://www.edinburgh.gov.uk/spaces-people-1/emergency-measures-pedestrians-cyclists-coronavirus` Retrieved on 12 April 2021.

[5] Sarah Butler. Cycling boom rolls on amid struggle to meet uk demand during covid. *The Guardian*, 21 March 2021. `https://www.theguardian.com/business/2021/mar/21/cycling-boom-rolls-on-amid-struggle-to-meet-uk-demand-during-covid` Retrieved on 12 April 2021.

[6] Vyas Padmanabhan, Praveena Penmetsa, Xiaobing Li, Fatema Dhondia, Sakina Dhondia, and Allen Parrish. Covid-19 effects on shared-biking in new york, boston, and chicago. *Transportation Research Interdisciplinary Perspectives*, 15 December 2020. `https://www.sciencedirect.com/science/article/pii/S2590198220301937` Retrieved on 12 April 2021.

[7] Songhua Hu, Chenfeng Xiong, Zhanqin Liu, and Lei Zhang. Examining spatiotemporal changing patterns of bike-sharing usage during covid-19 pandemic. *Journal of Transport Geography*, February 2021. `https://www.sciencedirect.com/science/article/pii/S0966692321000508` Retrieved on 12 April 2021.

[8] Just Eat Cycles. Historical data. April 2021. `https://edinburghcyclehire.com/open-data/historical` Retrieved on 12 April 2021.

[9] HM Government. Open government license for public sector information. *The National Archives*. `https://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/` Retrieved on 12 April 2021.

[10] Roy Thomson. Covid-19 and traffic volumes in edinburgh. *The University of Edinburgh*, 4 August 2020. `https://blogs.ed.ac.uk/roythompson/2020/08/04/covid-19-and-traffic-volumes-in-edinburgh/` Retrieved on 12 April 2021.

[11] K. Krishnamoorthy and Jessica Thomson. A more powerful test for comparing two poisson means. *Journal of Statistical Planning and Inference*, 15 July 2002. `https://userweb.ucs.louisiana.edu/~kxk4695/JSPI-04.pdf` Retrieved on 12 April 2021.

[12] Press Office. A look back at 2020. *Met Office*, 30 December 2020. `https://www.metoffice.gov.uk/about-us/press-office/news/weather-and-climate/2020/2020-round-up` Retrieved on 12 April 2021.

[13] The Scottish Government. Scottish index of multiple deprivation 2020. 2020. `https://www.gov.scot/collections/scottish-index-of-multiple-deprivation-2020/` Retrieved on 12 April 2021.

[14] Transport for London. Mayor's flagship cycling scheme - barclays cycle hire - opens for business. 30 July 2010. `https://tfl.gov.uk/info-for/media/press-releases/2010/july/mayors-flagship-cycling-scheme--barclays-cycle-hire--opens-for-business` Retrieved on 12 April 2021.