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# Can kerbside bicycle lanes increase cycling during a pandemic? A case study from Melbourne

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## Abstract

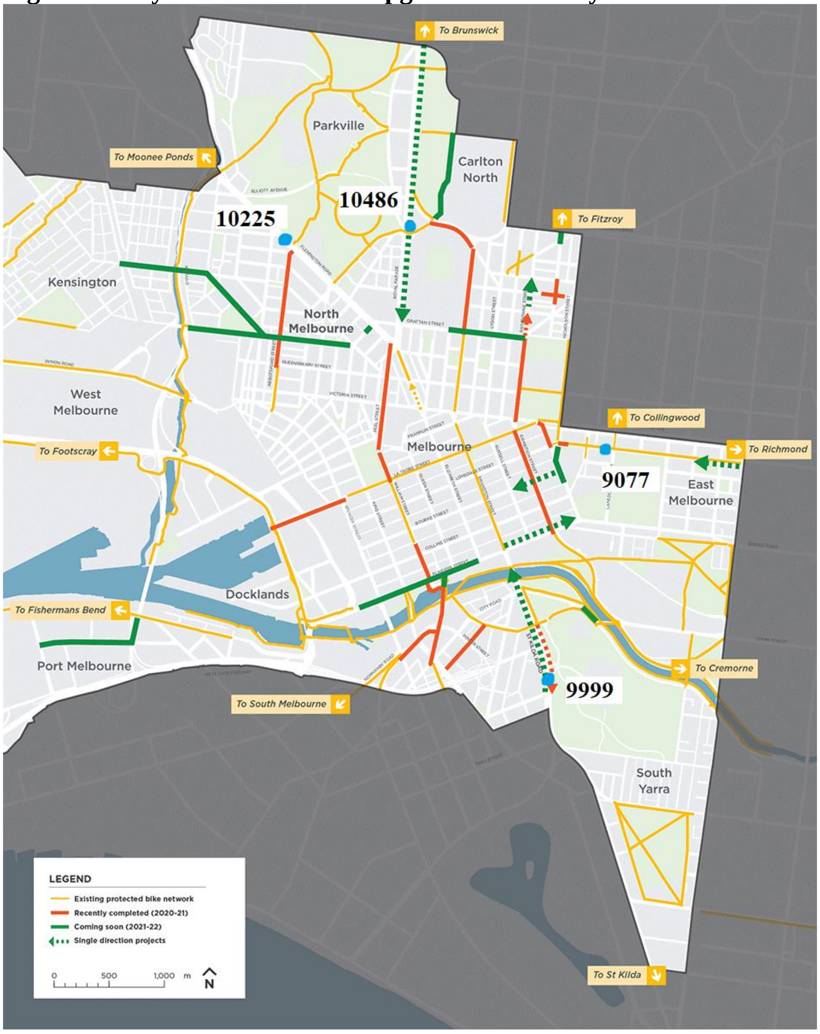
COVID-19 has dramatically changed how people travel in cities. Many cities saw significant increases in cycling rates during the pandemic, and in response some cities implemented temporary or permanent improvements in safe cycling infrastructure. However, further study found that cycling increases were primarily for recreation and exercise. In contrast, cycling for commuting declined, largely because commuting overall (especially into cities) has been partially replaced by working from home. In 2020 and 2021, the City of Melbourne fast-tracked a range of cycling infrastructure upgrades in an effort to attract more workers back into the city using this sustainable transport mode. This study examines whether trends in weekday cycling near the city are beginning to recover from the impacts of the pandemic, using bicycle count data from 15 automatic counters within 5km of the city centre. In addition, this paper quantifies the impact of COVID-era infrastructure upgrades. Negative binomial regression modelling found that weekday bicycle counts were significantly dampened during lockdown and remain 39% below pre-COVID levels. More importantly, even when controlling for lockdown stage and seasonality, counters near upgraded infrastructure had 22% higher average daily counts compared to non-upgraded sites. This increase is significant given that overall demand for travel into the city has decreased significantly. These findings are particularly relevant for cities that are grappling with whether to continue with temporary cycling infrastructure upgrades and cities that are struggling to encourage workers back into cities without relying on car travel. This study suggests that providing upgrades to cycling networks is an effective tool in this effort.

# 1. Introduction

During the COVID-19 pandemic, rates of cycling changed dramatically in many cities, gathering enormous attention in the literature. A number of cities documented increases in cycling rates during periods of lockdown and restrictions (Schweizer et al., 2021, Fuller et al., 2021). However, other studies found a significant *decrease* in cycling rates (Patterson et al., 2021). In particular, cycling was more likely to increase on weekends, during the middle of the day or as a form of recreation and exercise, and was more likely to decrease on weekdays, peak hour times or for trips to work (Buehler and Pucher, 2021, Hong et al., 2020a, Monfort et al., 2021). This is likely because cities have experienced long-term increases in rates of working from home, reducing the overall demand for commute travel (Anable et al., 2022). Commuting by bicycle may be one way to encourage workers back into cities using a mode that is socially distanced and sustainable.

At the same time, many cities implemented ‘pop up’ bicycle infrastructure to support these observed increases in cycling. One study of 394 cities around the world found that providing more infrastructure for walking or cycling was the most common response (Combs and Pardo, 2021). Like many cities, councils in Melbourne implemented temporary bicycle infrastructure or expedited plans for permanent upgrades. The City of Melbourne, in particular, ‘fast-tracked’ a range of projects in or near the city centre (City of Melbourne, 2021), see Figure 1.

**Figure 1: Bicycle infrastructure upgrades in the City of Melbourne**



*Note: blue dots and ID numbers show the location of bicycle counters near upgrades*

These upgrades are part of a strategy to increase bicycle ridership at a time when travel into the city has not recovered relative to 2019 levels. An increase in working from home has significantly reduced commuting into the city, especially by public transport and cycling (Deloitte, 2021).

If COVID-19 resulted in significantly lower commute trips by bicycle, it is worth examining whether commute cycling is beginning to recover, and whether upgrading bicycle infrastructure can help with this recovery process. For this reason, this paper aims to examine the impact of upgraded cycling infrastructure on cycling activity near Melbourne city centre.

The next section of this paper reviews studies on the impact of infrastructure upgrades on cycling counts. We then provide a description of the cycling count data used in this study as well as a description of the infrastructure upgrades studied. Then we present the descriptive and binomial regression modelling results, before finishing with a discussion of the implications for city policy.

# 2. Literature review

Upgrading infrastructure usually results in increased cycling, although the scale of increase depends on the project context. Some projects have incredibly significant impacts; when Lisbon significantly expanded their cycling infrastructure and provided a bike-sharing system, cyclist counts increased 817% across two years (Félix et al., 2020). But most projects were smaller in scale with smaller impacts. A study in the Singapore (where it is legal to cycle on a footpath) found a 44% increase in footpath cycling when the city widened footpaths (Nguyen et al., 2015). And after four cycling routes in Glasgow were upgraded, Strava counts suggest that cycling into Glasgow increased between 12% and 18% (Hong et al., 2020b).

Within Australia, implementing segregated cycling infrastructure also results in significant increases in cycling. When a 2.4km bicycle path was built in Sydney’s centre, counts increased between 23% and 97% one year later (Rissel et al., 2015). When a new ‘veloway’ was opened in Brisbane, there was a 69% increase in monthly bicycle counts in the short term (Heesch et al., 2016).

However, to date there has been little research on the impact of cycling upgrades during the era of COVID-19. One early study from Europe found that, on average, European cities implemented 11.5km of infrastructure which resulted in between 11% and 48% increase in cycling in the short term (Kraus and Koch, 2021). But this study was conducted in early 2020 and only considered ‘pop-up’ bike lanes. Since then many cities (including Melbourne) have made some or all of these upgrades permanent. At the same time, many cities have moved in and out of repeated waves of travel restrictions and lock-downs, and the trend toward greater working from home (and therefore less demand for commuting) looks set to continue.

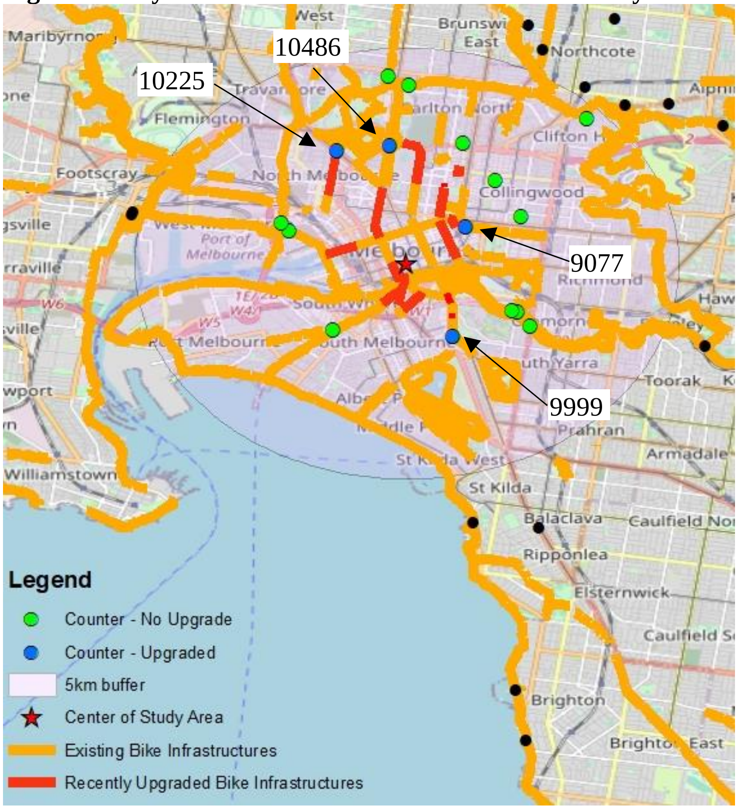
If cycling is to continue as a sustainable travel option in cities where travel demand to work has decreased, it is important to understand the impact of cycling upgrades in the context of COVID-19. For this reason, this paper aims to quantify the impact of cycling infrastructure upgrades on cycling activity throughout the first two years of the pandemic (from 2019 through 2021).

# 3. Methodology

## 3.1. Bicycle data source

The Victorian state government operates a set of permanent bicycle counters across the city, concentrated near the city centre and key cycling corridors. These counters log every bicycle by direction of travel as well as recording their speed of travel (note that the counts cannot distinguish potential duplicates of people crossing more than one counter). Figure 2 shows the location of all 15 counters within 5 kilometres of the centre of Melbourne (defined as Flinders Street Railway Station) relative to the recently upgraded bicycle infrastructure within the city of Melbourne. Counters outside of the 5 kilometre radius were considered outside the scope of this analysis. Table 1 describes the infrastructure immediately surrounding the 15 counters included in this study. Note that the bicycle counters were installed by the state government, and therefore do not necessarily align with the upgrade plans of the City of Melbourne.

**Figure 2: Bicycle counters within 5km of Melbourne city centre**



*Note: Black dots are bicycle counters excluded from the analysis*

Bicycle counts from 2019-2021 calendar years (January to December) were downloaded for each of these 15 counters. Although counts are recorded separately for each direction of travel, the bi-directional counts were summed into a daily total for this analysis. Some counters had periods of missing data due to malfunctioning equipment or upgrades to the counter location. In total, we included 16,067 valid data points in this analysis. Note that to focus on the impacts of infrastructure upgrades, we analyse the data by day (rather than by hour of the day) and did not use the data on cyclists' speeds.

**Table 1: Bicycle counters included in analysis**

| | ID | Before upgrade | After upgrade | Completion date |
|---|---|---|---|---|
| Upgraded | 10486 | Painted buffer lane | Kerbside protected bike lane | Oct 2020 |
| | 10225 | Painted buffer lane | Kerbside protected bike lane | Dec 2020 |
| | 9999 | Painted door-zone lane | Kerbside protected bike lane | Feb 2021 |
| | 9077 | Kerbside protected lane (ended before intersection) | Extended kerbside protected lane through intersection | June 2021 |
| Non-upgraded | 6415 | Off-road bike path | N/A | N/A |
| | 6592 | Off-road bike path | | |
| | 7588 | Off-road bike path | | |
| | 8172 | Off-road bike path | | |
| | 8176 | Off-road bike path | | |
| | 8180 | Off-road bike path | | |
| | 10484 | Off-road bike path | | |
| | 33179 | Off-road bike path | | |
| | 7600 | Painted door-zone lane | | |
| | 32493 | Painted door-zone lane | | |
| | 34314 | Painted door-zone lane | | |

The bicycle infrastructure in the study area was classified into one of four types:

- Painted ‘door-zone’ lane: A bike lane demarcated with paint and placed between a lane of parked cars and a lane of motorised traffic
- Painted buffer lane: A bike lane with a painted buffer between the bike lane and the motorized traffic and/or parking lane
- Kerbside protected lane: A bike lane between the footpath and a parking and/or vehicle traffic lane, protected by a raised kerb
- Off-road bike path: Off-road but shared with pedestrians

Only four of the 15 counters were considered to be ‘upgraded’ during the study period (shown in blue in Figures 1 and 2) because they were within 400m of an upgrade undertaken in 2020 or 2021. All four upgrades involved providing kerbside protected lanes, although the extent of the upgrade varied in scope from small segments (i.e. extending kerbside protection 50m around an intersection for site 9077) to upgrades of over 1 kilometer in length. Examples of upgrades are presented in Figure 3. The majority of the non-upgraded counters (shown in green in Figure 2) were on off-road bike paths.

**Figure 3: Examples of infrastructure upgrades**

10486 Painted buffer | 10486 Kerbside protected | 10225 Painted buffer | 10225 Kerbside protected

9999 Painted door-zone | 9999 Kerbside protected | 9077 Kerbside ended before intersection | 9077 Kerbside protected extended

## 3.2. Analysis method

The bicycle counter data was first examined descriptively. To isolate the effect of infrastructure upgrades, we conducted a multivariate regression. First, we tested whether the dependent variable (daily bicycle count) conformed to a Poisson or negative binomial distribution. The distribution exhibited overdispersion (the variance was greater than the mean) and the Kolmogorov-Smirnov test was statistically significant; both of these indicators suggest that a Poisson regression is not a good fit. Therefore, a negative binomial regression was employed.

To estimate the daily bicycle counts, a range of independent variables were included. These included:

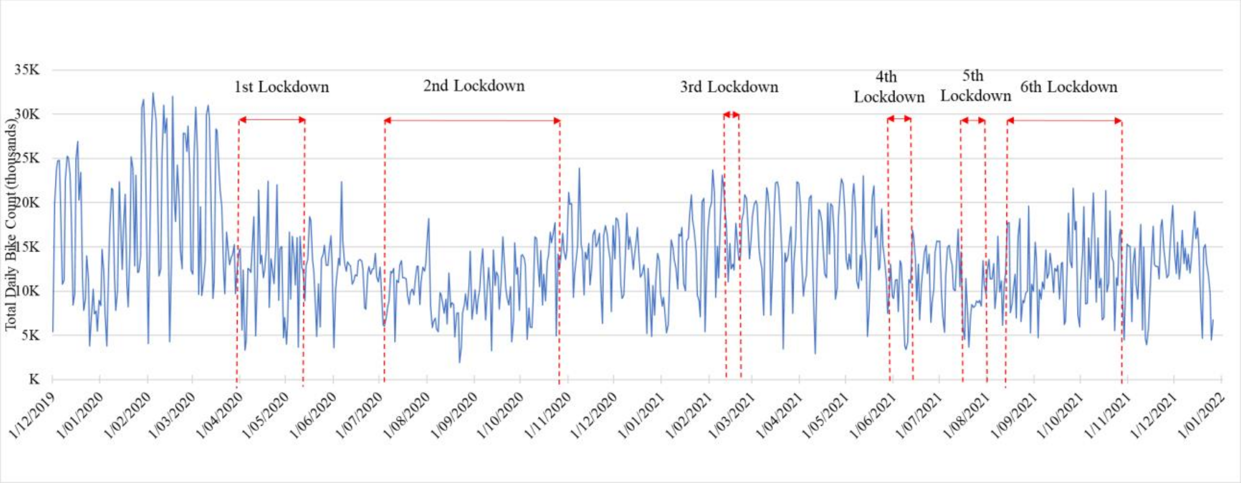
- Upgraded or not
- Weekday vs. weekend
- Month of the year (to control for seasonality)
- Infrastructure type nearest to counter
  - Painted door-zone
  - Painted buffer
  - Kerbside protected
  - Off-road path
- Lockdown stage
  - Pre-COVID
  - Lockdown: active stay-at-home orders in place)
  - 'Lockdown buffer': after a lockdown ended, restrictions eased gradually. For example, many workplaces continued a 'work from home' directive for some time after a period of lockdown ended. For this reason, we coded any days within 4 weeks of a lockdown ending as a 'lockdown buffer' time period.
  - Post-lockdown: any period after the four-week 'lockdown buffer'

# 4. Results

## 4.1. Descriptive results

Between 2020 and 2021 Melbourne was in some form of lockdown for a total of 264 days across 6 periods of lockdown. Figure 4 presents the overall daily bicycle counts for the 15 counters within 5km of Melbourne. These raw count data make it difficult to draw any general conclusions as cycling rates are highly seasonal and depend on day of the week, lockdown stage and infrastructure type.

**Figure 4: Total daily bicycle counts, December 2019 to December 2021**



*Note: combined data from 15 counters within 5km of Melbourne city centre*

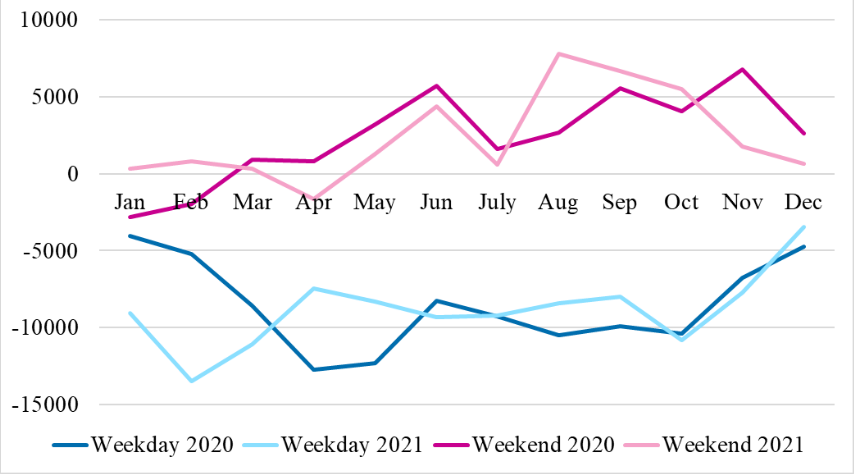
Table 2 shows the average daily bicycle counts for each counter. The daily counts varied significantly between 317 bicycles/day and 2521 bicycles/day. At almost every site, average counts declined between 2019 and 2020/2021, regardless of whether the site was upgraded or not. The only exception is site ID 10486, where counts increased in 2021 to the same levels as 2019.

**Table 2: Average daily bicycle counts by counter ID**

| | Counter ID | Infrastructure type | Average daily count 2019 | 2020 | 2021 |
|---|---|---|---|---|---|
| Upgraded | 10486 | Painted buffer lane | 1176 | 739 | |
| | | Kerbside protected | | 1162 | 1180 |
| | 10225 | Painted buffer lane | 729 | 441 | |
| | | Kerbside protected | | | 416 |
| | 9999 | Painted door-zone lane | 1176 | 799 | 852 |
| | | Kerbside protected | | | 614 |
| | 9077 | Kerbside protected | 1075 | 556 | 573 |
| Non-upgraded | 6415 | Off-road bike path | 1644 | 1149 | 1086 |
| | 6592 | Off-road bike path | 2521 | 1642 | 1429 |
| | 7588 | Off-road bike path | 1643 | 1449 | 1342 |
| | 8172 | Off-road bike path | 1393 | 577 | 412 |
| | 8176 | Off-road bike path | 470 | 814 | 618 |
| | 8180 | Off-road bike path | 1581 | 1388 | 1200 |
| | 10484 | Off-road bike path | 1046 | 786 | 773 |
| | 33179 | Off-road bike path | 1085 | 887 | 884 |
| | 7600 | Painted door-zone lane | 719 | 317 | 658 |
| | 32493 | Painted door-zone lane | 1749 | 1318 | 1095 |
| | 34314 | Painted door-zone lane | 2015 | 572 | 1038 |

Figure 5 examines whether ridership on weekends shows a different trend than weekdays. It shows the combined counts averaged across a given month and shown relative to the same month in 2019. There were considerable differences in trends for weekend versus weekdays. Weekday ridership never returned to 2019 levels, even in December and January when Melbourne was never in a period of lockdown. In contrast, weekend ridership was above the 2019 baseline for all but three months. Even though these counters were all within 5km of the city centre, it appears that weekend (recreational) ridership increased in popularity during the first two years of the pandemic.

**Figure 5: Change in monthly bicycle counts relative to same month in 2019, weekday vs. weekend**



## 4.2. Modelling results

Many factors influence bicycle counts including lockdown stage, weekday/weekend and infrastructure type. For this reason, negative binomial regression models were run to isolate the potential effect of infrastructure upgrades when these other factors are controlled for. Due to the obvious interaction between lockdown stage and weekday vs weekend, two versions of the model were run. The first only includes the main effects listed in section 3.2; the second includes an interaction between lockdown stage and weekend/weekday.

Table 3 presents the overall model fit values for these models. Both models were a statistically significant fit using the Likelihood Ratio Chi-Square test, and Model B had slightly lower AIC, AICC, BIC and CAIC values. For this reason, the model including the interaction effect will be presented in the rest of the paper.

**Table 3: Overall model fit for negative binomial regression models**

| | Model without interaction effect | | Model with interaction effect | |
|---|---|---|---|---|
| | Value | df | Value | df |
| Likelihood Ratio Chi-Square | 7632 | 17 | 9798 | 20 |
| Log Likelihood | -121143 | | -120060 | |
| Akaike's Information Criterion (AIC) | 242324 | | 240164 | |
| Bayesian Information Criterion (BIC) | 242470 | | 240334 | |
| Consistent AIC (CAIC) | 242489 | | 240356 | |

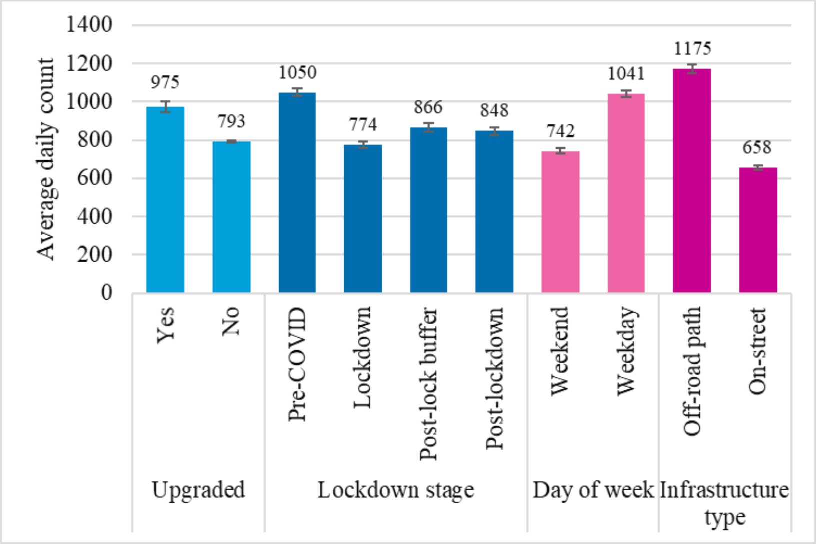
Table 4 presents the results of the negative binomials regression model. Every variable in this model, including the interaction, was highly statistically significant ($p < .001$). The most intuitive way to interpret these models is to consider the Exp(B) column as similar to an odds ratio – values greater than 1 mean that counts are higher under that factor whereas values less than 1 mean that counts are lower under that value. When all else is held constant, cycling counts are higher if a location is near an upgrade, if a location is an off-road bicycle path and if the count was taken on a weekend during or during a post-lockdown buffer period. Counts were also seasonal with higher values recorded in the warmer months, except for December and January (likely because of school holidays).

The scale of these effects is best explored using estimated marginal means, which is the mean value of daily counts provided by the model when all variables are controlled for. Figure 6 presents the main effects of the model (omitting the monthly effects). The key variable of interest is the effect of upgrading nearby infrastructure; when all other effects are accounted for, upgrading nearby infrastructure increased daily counts by 22% (from 793 to 975). In addition, being in a lockdown period reduced counts by 26% (from 1050 to 774) and remained about 18% lower during both the 4-week post-lockdown buffer and the remaining post-lockdown period. Weekday counts were 40% higher than weekends (1041 vs 742) and counts on off-road paths were 78% higher than count at on-street sites (1,175 vs 658). However, because the interaction between lockdown stage and weekend/weekday was significant, those values should be considered alongside the interaction effect shown in Figure 7.

**Table 4: Negative binomial regression model predicting daily bicycle counts**

| | | Wald Chi-Square | B | Std. Error | Exp(B) | Lower 95% CI | Upper 95% CI |
|---|---|---|---|---|---|---|---|
| Intercept | | 208056.4 | 7.00 | 0.015 | 1097.36 | 1064.84 | 1130.87 |
| Upgraded [relative to not] | | 164.3 | 0.21 | 0.016 | 1.23 | 1.19 | 1.27 |
| Pre-COVID [reference] | | | | | 1 | | |
| Lockdown | | 3653.7 | -0.82 | 0.014 | 0.44 | 0.43 | 0.45 |
| Post-lockdown buffer | | 1358.8 | -0.58 | 0.016 | 0.56 | 0.55 | 0.58 |
| Post-lockdown | | 1317.7 | -0.49 | 0.014 | 0.61 | 0.60 | 0.63 |
| Weekend [relative to weekday] | | 3653.7 | -0.82 | 0.014 | 0.44 | 0.43 | 0.45 |
| Off-road path [relative to on-road] | | 4750.1 | 0.60 | 0.008 | 1.79 | 1.76 | 1.82 |
| January [reference] | | | | | 1 | | |
| February | | 133.2 | 0.23 | 0.020 | 1.25 | 1.21 | 1.30 |
| March | | 39.5 | 0.12 | 0.019 | 1.13 | 1.09 | 1.17 |
| April | | 29.8 | 0.11 | 0.020 | 1.11 | 1.07 | 1.16 |
| May | | 4.6 | 0.04 | 0.019 | 1.04 | 1.00 | 1.08 |
| June | | 31.3 | -0.11 | 0.020 | 0.90 | 0.86 | 0.93 |
| July | | 49.5 | -0.14 | 0.020 | 0.87 | 0.84 | 0.91 |
| August | | 32.5 | -0.12 | 0.021 | 0.89 | 0.85 | 0.93 |
| September | | 0.2 | 0.01 | 0.021 | 1.01 | 0.97 | 1.05 |
| October | | 31.1 | 0.12 | 0.021 | 1.12 | 1.08 | 1.17 |
| November | | 12.0 | 0.07 | 0.021 | 1.08 | 1.03 | 1.12 |
| December | | 1.3 | -0.02 | 0.020 | 0.98 | 0.94 | 1.02 |
| Interaction effect | Pre-COVID weekend [reference] | | | | 1 | | |
| | Pre-COVID weekday [reference] | | | | 1 | | |
| | Lockdown weekend | 2098.2 | 1.02 | 0.022 | 2.78 | 2.66 | 2.91 |
| | Lockdown weekday [reference] | | | | 1 | | |
| | Buffer weekend | 809.6 | 0.77 | 0.027 | 2.15 | 2.04 | 2.27 |
| | Buffer weekday [reference] | | | | 1 | | |
| | Post-lock weekend | 548.4 | 0.55 | 0.024 | 1.73 | 1.66 | 1.82 |
| | No lockdown weekday [reference] | | | | 1 | | |

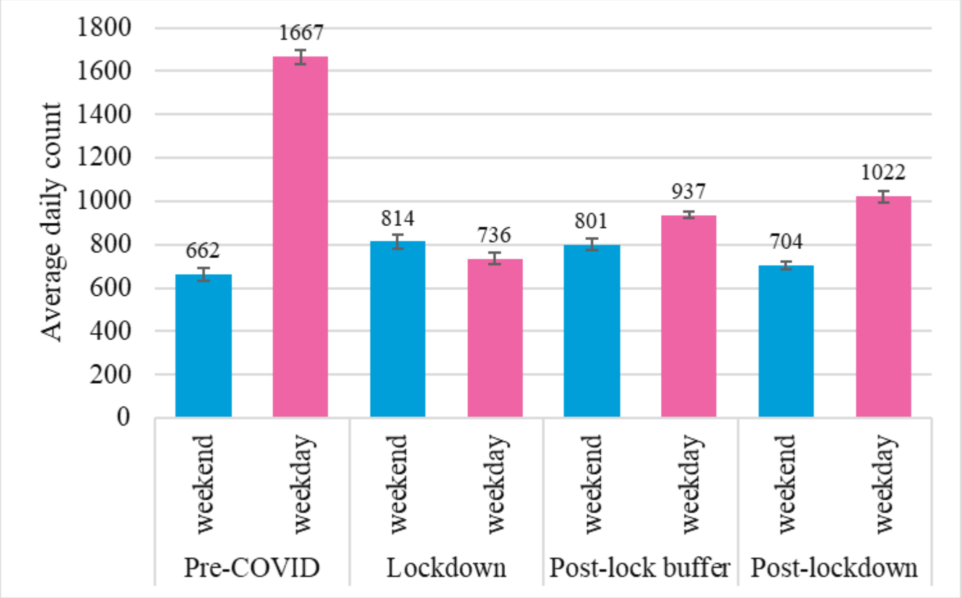
**Figure 6: Estimated marginal means of average daily bicycle counts for main effects of regression model**



*Note: error bars represent 95% Wald Confidence Interval*

Figure 7 shows that the effect of weekday vs weekend depended on the stage of lockdown. Before COVID-19, counts were more than twice as high on weekdays (1,667) compared to weekends (662). During lockdown this pattern reversed with 11% *higher* ridership on weekends (814) compared to weekdays (736). In the post-lockdown stages, weekend ridership has remained above pre-COVID times. In contrast, although weekday counts increased post-lockdown it is still 39% below pre-COVID levels.

**Figure 7: Estimated marginal means of the interaction between day and lockdown stage**



*Note: error bars represent 95% Wald Confidence Interval*

## 5. Discussion

This paper examined the impact that upgrading infrastructure can have on bicycle counts during the early years of the COVID-19 pandemic. Many cities implemented temporary or permanent cycling upgrades during the pandemic. Yet it can be difficult to isolate the effects of infrastructure upgrades when the pandemic itself has such a significant impact on cycling rates. COVID-19 travel restrictions significantly dampen the demand for travel more generally, which may in turn mask the effects of cycling infrastructure upgrades.

Using data from 15 cycling counters within 5 kilometers of Melbourne's CBD, we found that cycling counts dropped by 26% during periods of lockdown and 18% in the four weeks immediately after lockdowns were lifted. However, this effect depended on whether the counts were taken on a weekday or weekend. Outside of lockdown, weekday counts near the city centre were more than twice as high as weekend counts, demonstrating the use of these locations for commuting into the city. However, during lockdown the weekend count actually *increased* by 11%, suggesting that even this close to the city people were taking advantage of cycling infrastructure for exercise or outdoor recreation at a time when both of those options were severely limited. This is consistent with recent COVID-19 research from other countries where cycling was more likely to increase on weekends or during the middle of the day (Hong et al., 2020a, Monfort et al., 2021).

After controlling for lockdown stage, day of the week, seasonality and infrastructure type, we found that upgrading nearby infrastructure increased counts by 22%. This effect is comfortably within what has been found in past research, where upgrading infrastructure increased ridership by 12% to 97%, depending on the project scale and context (Nguyen et al., 2015, Hong et al., 2020b, Heesch et al., 2016, Rissel et al., 2015). This effect is significant from a policy perspective, given the limitations of the study. First, the effects were detected even though some sites were upstream or downstream of upgrades. The measurement of the effect would be more precise if counters had been embedded within upgraded infrastructure, however we were constrained by data availability. Second, the effects detected in this model should be considered short-term as the upgrades were completed between 6 and 14 months from the end of the study period. Third, some of the upgrades were relatively minor compared to other cities which provided more expansive upgrades or fully separated 'veloways'. Finally, the effects are measured at a time when overall demand for cycling into the city is severely dampened. Working from home has significantly increased as a result of the pandemic, and the jobs that are more likely to be done from home are concentrated in the city center. Indeed, the average weekday bicycle counts were still 39% below pre-pandemic levels even more than 4 weeks after lockdown restrictions eased. Given these three constraints, it is noteworthy that these upgrades had any measurable effect at all.

These findings are particularly relevant for cities that are struggling with the decision of whether to reverse temporary changes to cycling infrastructure. Given that COVID-19 and the increase in working from home is likely to be shaping our society for some time, it is likely that many cities will be struggling to encourage people back into their cities. This study suggests that providing upgrades to cycling networks is an effective tool in this effort.

# 6. References

Anable, J., Brown, L., Docherty, I. & Marsden, G. 2022. Less is more: Changing travel in a post-pandemic society. Oxford, UK: Centre for Research into Energy Demand Solutions.

Buehler, R. & Pucher, J. 2021. COVID-19 Impacts on Cycling, 2019–2020. Taylor & Francis.

City of Melbourne. 2021. *New bike lanes* [Online]. Available: https://www.melbourne.vic.gov.au/building-and-development/shaping-the-city/city-projects/Pages/new-bike-lanes.aspx# [Accessed 3 May 2022 2022].

Combs, T. S. & Pardo, C. F. 2021. Shifting streets COVID-19 mobility data: Findings from a global dataset and a research agenda for transport planning and policy. *Transportation Research Interdisciplinary Perspectives,* 9**,** 100322.

Deloitte 2021. City of Melbourne Independent Transport Review. Melbourne.

Félix, R., Cambra, P. & Moura, F. 2020. Build it and give 'em bikes, and they will come: The effects of cycling infrastructure and bike-sharing system in Lisbon. *Case studies on transport policy,* 8**,** 672-682.

Fuller, G., Mcguinness, K., Waitt, G., Buchanan, I. & Lea, T. 2021. The reactivated bike: Self-reported cycling activity during the 2020 COVID-19 pandemic in Australia. *Transportation research interdisciplinary perspectives,* 10**,** 100377.

Heesch, K. C., James, B., Washington, T. L., Zuniga, K. & Burke, M. 2016. Evaluation of the Veloway 1: A natural experiment of new bicycle infrastructure in Brisbane, Australia. *Journal of Transport & Health,* 3**,** 366-376.

Hong, J., Mcarthur, D. & Raturi, V. 2020a. Did safe cycling infrastructure still matter during a covid-19 lockdown? *Sustainability,* 12**,** 8672.

Hong, J., Mcarthur, D. P. & Livingston, M. 2020b. The evaluation of large cycling infrastructure investments in Glasgow using crowdsourced cycle data. *Transportation,* 47**,** 2859-2872.

Kraus, S. & Koch, N. 2021. Provisional COVID-19 infrastructure induces large, rapid increases in cycling. *Proceedings of the National Academy of Sciences,* 118.

Monfort, S. S., Cicchino, J. B. & Patton, D. 2021. Weekday bicycle traffic and crash rates during the COVID-19 pandemic. *Journal of Transport & Health,* 23**,** 101289.

Nguyen, P. N., Koh, P. P. & Wong, Y. D. Impacts of bicycle infrastructure: a case study in Singapore. Proceedings of the Institution of Civil Engineers-Municipal Engineer, 2015. Thomas Telford Ltd, 186-198.

Patterson, R., Ogilvie, D. & Panter, J. 2021. Travel Levels Before and After COVID-19 Control Measures in Cambridge, UK.

Rissel, C., Greaves, S., Wen, L. M., Crane, M. & Standen, C. 2015. Use of and short-term impacts of new cycling infrastructure in inner-Sydney, Australia: a quasi-experimental design. *International Journal of Behavioral Nutrition and Physical Activity,* 12**,** 1-8.

Schweizer, A.-M., Leiderer, A., Mitterwallner, V., Walentowitz, A., Mathes, G. H. & Steinbauer, M. J. 2021. Outdoor cycling activity affected by COVID-19 related epidemic-control-decisions. *Plos one,* 16**,** e0249268.