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Weekday bicycle traffic and crash rates during the COVID-19 pandemic

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ABSTRACT

Introduction: One of the most consequential effects of the COVID-19 lockdowns was a dramatic reduction in travel during peak hours. Transportation modes also shifted—in particular, travel by car became more rare while bicycling saw a resurgence. Given that a typical year sees the most severe bicycle crashes in peak commuter traffic, the shift toward bicycle travel that occurred in 2020 will likely have been accompanied by unique changes in rider behavior (e.g., where and when they choose to ride) as well as the frequency and severity of vehicle-bicycle crashes.

Methods: The current study compared weekday bicycle traffic and crashes in Arlington, VA from March–December 2020 with the same period from years prior, 2013–2019. Bicycle traffic data were obtained from 16 embedded counters placed throughout the study area, in both off-road trails and on-road bike lanes.

Results: We found that 2020 midday traffic nearly doubled compared to the year before, increasing from an average of 68 riders per hour to 120 (+76%). By contrast, morning traffic fell from an average of 87 riders per hour to just 45 (−49%). Change in evening traffic depended on the location of the counters: more evening bicycles were counted on off-road, multi-use trails (+6%) but fewer on on-road lanes (−27%). The changes to 2020 bicycle traffic patterns were also associated with a 28% reduction in bicycle injury crash rate per counted cyclist.

Conclusion: The reduced crash risk observed in 2020 was likely due in part to the reduction of morning, on-road bicycle travel, which past research has found to be particularly dangerous for riders. Conversely, the availability of multi-use off-road trails seems to have been a protective factor against bicycle-motor vehicle crash risk in the face of greater bicycle travel volume.

1. Introduction

The 2019 coronavirus (COVID-19) pandemic has drastically altered the transportation needs of individuals around the world. Perhaps the most notable change in these needs is an overall reduction in mobility for most people (Aloi et al., 2020; Shilling and Waetjen, 2020). The reduction in overall mobility happened alongside a redistribution in the popularity of different transportation methods. The risk for disease transmission in public transport, for example, shifted mobility toward individual methods, such as driving, biking, and walking (Teixeira and Lopes, 2020; Wang et al., 2021). Bicycle use in particular has experienced a growth in popularity in countries around the world (Brooks et al., 2021; Buehler and Pucher, 2021; Department for Transport, 2021; The NPD

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The current study was conducted to contribute to the growing body of research characterizing the change in bicycle travel during the COVID-19 pandemic. Specifically, we examined how hourly weekday bicycle use changed in Arlington, Virginia following the onset of statewide restrictions related to COVID-19 in March 2020 until the end of the calendar year. We also examined the change in the bicycle crash rate per 100,000 counted riders over the same time period. Analyzing the changes in travel and crash rates that resulted from the COVID-19 pandemic is important for a variety of reasons. Movement restrictions present an opportunity for researchers to characterize how transportation networks respond to stress. Further, aspects of the changes to travel observed in 2020 will persist to some degree after COVID-19 is no longer a public health risk, and so understanding how mobility changed in 2020 may be useful for understanding needs in the years to come. The changes to transportation patterns and crash rates that we have observed this year may far outlast the pandemic itself and so we should seek to characterize them as accurately as possible.

Preliminary research on the transportation-related effects of the COVID-19 pandemic has shown a consistent pattern. First and foremost, overall mobility by any mode declined as people were less willing and able to travel as they might normally. Although an exact estimate for overall mobility loss is difficult to establish—the magnitude of this effect likely depends on the locality in question and the severity of the travel restrictions in place at the time—research thus far has found estimates ranging between —35% (Stavrinos et al., 2020) and —80% (Shilling and Waetjen, 2020). The greatest losses in mobility seem to have taken place in the morning and late afternoon, where people would otherwise be commuting to and from work (Aloi et al., 2020; Li et al., 2020). Large numbers of unemployed or teleworking makes any method of transit for work purposes irrelevant. Of the traffic that remains, researchers have observed a shift away from public and mass transportation and toward driving, walking, and biking (Möllers et al., 2021; Teixeira and Lopes, 2020; Wang et al., 2021). A shift toward solitary travel has been observed all around the world: in Spain (Aloi et al., 2020), the United States (Stavrinos et al., 2020; Shilling and Waetjen, 2020; Wang et al., 2021), the United Kingdom (Brooks et al., 2021), Switzerland (Mollo et al., 2020), Greece (Nikiforianidis et al., 2020), and Chile (Astroza et al., 2020).

Cycling in particular has increased in popularity during the pandemic; survey research suggests a boost across all genders, most age groups, and all social classes (Brooks et al., 2021). A representative sample of U.S. adults found decreases in local travel for nearly all modes of transport, but no such decline was observed for bicycle trips (Ehsani et al., 2021). Further, sales of private bicycles in the United States saw huge growth in early 2020: compared to the same period the year before, sales of leisure bicycles (basic adult bicycles sold for less than $200) grew by more than 200% (NPD Group, 2021). Consumer spending on bicycle accessories also grew in 2020, including helmets (+49%), water bottle cages (+60%), and bike baskets (+85%; NPD Group, 2021). Among a group of 11 EU countries with automatic bicycle counters, data suggests an overall increase of 8% in bicycle traffic from 2019 to 2020; this comparison in the United States found 16% growth over the same period (Buehler and Pucher, 2021). Increased bicycle use during the pandemic seems to have stemmed largely from growth in weekend recreational travel. Two large networks of mostly off-road, multi-use trails in the United States saw record traffic in 2020, recording a growth of 48% (Rails-to-Trails; RTC, 2021) and 50% (The East Coast Greenway; ECG, 2020). By contrast, growth in weekday bicycle traffic was relatively small (Fischer and Winters, 2021; Geiger et al., 2021). Reduced need for commuting likely underlies this effect, as fewer people were traveling to work, university, or school in 2020 compared to past years. Bikeshare data from New York City, for example, saw reductions in rental volume exclusively during weekdays (Li et al., 2020). In sum, extant data suggests that bicycle traffic has increased during the pandemic, but that this increase was largely restricted to weekends where riders are engaging in recreational activity.

Changes to daily bicycle traffic seem dependent on local infrastructure and other location-specific moderating variables. For example, Zhang and Fricker (2021) found that daily bicycle traffic across the United States decreased in densely populated cities but increased in less populated ones. Doubleday et al. (2021) found a similar effect, with New York City bicycle traffic decreasing following the stay-at-home order, Houston traffic increasing, and Seattle traffic increasing or decreasing depending upon the location of the bicycle counter. A survey of cycling trends in the 100 largest US metropolitan areas found similar nuances, with a large amount of variance in the degree and extent of changes in bicycle traffic by location (Buehler and Pucher, 2021; Streetlight, 2020). Thus, although there has been a consistent overall shift toward bicycle use, the mechanisms underlying this shift are complex. The change in bicycle traffic for a given region seems to be related to the popularity of cycling as a means of commuting in that region, as well where the bicycle counters are located (proximity to work-related activities, etc.). Preliminary research on counters throughout North Carolina, for example, found traffic to decrease near commercial zones and university campuses but increase in off-road recreational areas (Geiger et al., 2021). It is clear that a complete understanding of how COVID-19 has affected bicycle travel cannot rely on daily count summaries from solitary counting stations.

It remains unclear what effect greater bicycle traffic in 2020 might have had on crash risk for those riders. The National Highway Traffic Safety Administration (NHTSA) reported a 7.2% increase in vehicle crash fatalities between 2019 and 2020 despite significantly fewer miles traveled, representing the single largest increase in motor vehicle fatality risk for nearly 100 years (National Highway Traffic Safety Administration, 2021). Excess speed seems to be a major contributing factor to the increase in vehicle crash risk observed for 2020; with less traffic, drivers seem to be more tempted to speed (Vingilis et al., 2020). Bicyclists riding among fewer but faster moving vehicles may be at risk for more severe injury in the event of a crash. Further, the surge in new bicycle sales in 2020 (e.g., NPD Group, 2021) suggests that novice riders may be more numerous compared to past years, and these riders typically are at higher risk for crash injury compared to riders with more experience (Hezaveh et al., 2018; Martínez-Ruiz et al., 2014). The current study was conducted to provide clarity regarding changes to weekday bicycle traffic, as well as how fewer commuters and more recreational riders affect bicycle traffic volume, rider preferences (whether they use on-road bike lanes or off-road trails), and crash rate.
2. Method

2.1. Bicycle traffic data

Bicycle traffic data were recorded using 32 counters placed along popular on-road bike lanes and off-road trails in Arlington County, Virginia. Arlington is a high-income semiurban county with a high population density situated across the Potomac River from Washington, D.C. As of 2019, the network of multi-use trails and bike lanes in Arlington included 52 miles of paved, off-road trails and 37 miles of on-road lanes. These routes have remained relatively unchanged over the past decade, expanding at a rate of roughly a mile per year (Arlington County Division of Transportation, 2020). Most of the on-road lanes (78%) carry bicycle traffic that is separated from vehicle traffic only by a painted line. Off-road trails are entirely separate from roads except at periodic crossing points, where bicycle traffic flows across vehicle traffic. The traffic counters along the bike lanes and trails passively record the passage of any bicycle that crosses them 24 h a day, 7 days a week. The current study examined bicycle counts in batches of 15-minute intervals on weekdays between 5AM and 10PM, March–December for 2013–2020. Counters that contained more than 10% missing data overall or more than one day of missing data in 2020 were excluded. Counters that were installed during the study period (i.e., after January 2013) were also excluded. Missing traffic data for 2013–2019 were imputed using the average traffic count for that hour and day combination.

The final sample of counters was reduced to just 16 counters (6 lanes and 10 trails). Each of the 10 trail counters were members of a pair, situated on either side of the trail counting traffic headed in different directions. Restricting our data to include only counters without large periods of missingness allows us to make more accurate statements about changing traffic levels over time. To ensure that the excluded counters were equivalent to those that were ultimately included in the analysis, we correlated the non-missing portions of the excluded counters with the included set for each hour in the data. The average correlation between the excluded counters and the counters in the final dataset was quite high \( r = 0.89 \). Thus, it is unlikely that excluding lossy counters biased our bicycle traffic data in a systematic way, and consequently we believe that the 16 remaining counters in the final dataset still provide a complete picture of bicycle traffic in Arlington. In other words, the excluded counters seem to have malfunctioned at random rather than as a result of systematic features of the locations at which they were installed.

In all, we analyzed 9.15M bicycle counts (about 114,000 per day on average). The final sample of counters included a suitable mix of on-road lane counters and off-road trail counters that were well-distributed around the county. A map of these counters is depicted in Fig. 1, as well as a depiction of the “Arlington Loop,” a route representing the most commonly traveled trails and lanes.

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Fig. 1. Red circles represent the placement of bicycle counter stations included in the current study; red path represents an approximation of the “Arlington Loop” as depicted by the County. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)
2.2. Crash data

Bicycle crash data were made available by the Virginia Department of Transportation. This dataset included police crash records from both Arlington and State police involving a motor vehicle where death or an injury were reported or at least $1500 of property damage occurred. The current study focused on crashes where a cyclist was injured that occurred during the same period as the traffic data: weekdays between March and December for 2013–2020.

2.3. Analysis

A continuous distribution can be modeled as a composite of several component distributions. Weekday bicycle traffic typically assumes a bimodal distribution, with a pair of strong commuter-related peaks. The overall traffic distribution can therefore be understood as a merging of a morning commuter group and an afternoon commuter group. Rather than assign cut-points manually—for example, assigning any rider counted before 12:00 p.m. to a “morning” group and likewise any rider after 12:00 p.m. to an “afternoon” group, we used finite mixture models to decompose the overall distribution into a number of component normal distributions. This procedure can be used to determine the ideal number of component distributions—one, two, or perhaps even three (Fig. 2). In sum, finite mixture models provide a bottom-up way to estimate 1) the number of rider groups, and 2) the probability of each rider belonging to the groups based on the time they were counted.

The relative density of each of the rider groups specified by the finite mixture models can then be used to estimate the number of cyclists that belong to them. In the case of a three distribution solution, for example, the model would divide the total density of bicycle traffic for each year between morning (x), midday (y), and evening (z) riders, where x + y + z = 1. A year with 1 million total riders, 35% morning riders (x = 0.35), 15% midday riders (y = 0.15), and 50% evening riders (z = 0.50) would have 350K morning riders, 150K midday riders, and 500K evening riders.

3. Results

3.1. Traffic data

Overall bicycle counts were relatively consistent between 2013 and 2019, but a slight downward trend can be observed from 2016 to 2019, with a year-over-year decrease of about 5%. (Fig. 3). From 2019 to 2020, the sample of counters included in this study saw about 43,842 more cyclists in (a 4% increase).

Separating traffic by hour of the day reveals the expected bimodal distribution, with one peak centered in the early morning and a second in the late afternoon. There also appears to be a smaller midday “floor” of about 200 riders per hour that stretches between the two commuter peaks. This pattern manifests in all years until 2020 (Fig. 4), when the shape of the distribution changes.

3.2. Rider type analysis

All counters. Comparing model fit (Akaike Information Criterion) between one, two, and three component solutions using aggregated 2013–2020 data found the three-component model to best fit the data. A three-component model was then fit to each year individually, producing a mean and standard deviation for each of the component distributions. The distributions specified by this procedure are depicted in Fig. 5 below.

Compared to riders in 2019, riders in 2020 were less likely to be counted during the morning and were correspondingly more likely to be counted during the midday. These changes represent a reduction from 87 morning riders per hour to just 45 in 2020, a 49% reduction from 2019; and an increase from 68 midday riders per hour to 120 in 2020, a 76% increase from 2019. The number of evening cyclists in 2020 remained essentially unchanged from 2019 (0.8% increase). The magnitude of changes observed for morning and midday cyclists far exceeded fluctuations observed between 2013 and 2019 (Fig. 6).

Lanes and trails. Off-road trails are less exposed to traffic compared to on-road lanes, and—in the case of Arlington—contain uninterrupted routes through parks and other recreational areas. Thus, by examining the change in traffic separately by counter type
we can gain some insight about the nature of the changes to morning, midday, and afternoon traffic (Fig. 7). For both trails and lanes, morning rider counts decreased while midday rider counts increased. However, on-road lanes and off-road trails had a different effect among evening riders. In 2020, there were 22,989 fewer evening riders counted on the lanes, or a 27% reduction from 2019. In contrast, there were 25,943 more evening riders counted on the trails, or a 6% increase from 2019. This difference between lanes and trails may be the result of riders moving away from commuting in the evening and toward more recreational riding.
Commuter routes. If we assume that the morning and evening peaks between 2013 and 2019 are the result of regular commuter activity, it is possible to rank each counter location according to the size of these peaks. We can then make inferences about the degree to which each trail is used for commuting. For example, a counter where 90% of daily traffic occurs in the morning and evening is likely a popular commuter route; in contrast, a counter where daily traffic is spread evenly throughout the day would be an unlikely commuter route. To establish a set of most popular commuter routes, we estimated individual finite mixture models for each of the counters for 2013–2019 and ranked them according to their morning and evening rider densities. On average, the morning and evening peaks for the counters accounted for 74% of daily riders (SD = 7%), ranging from a low of 62% to a high of 85%.

We then compared the six “commuter routes”, defined as those where 80% or more of daily traffic occurred during likely commuter hours (i.e., the morning and evening), with the remaining “non-commuter routes”. The six commuter routes were comprised of four lanes and two trails; the commuter trail counters were on either side of Francis Scott Key Bridge, a popular crossing route between Arlington and Washington, D.C. Between 2013 and 2019, the amount of daily traffic on commuter routes and non-commuter routes was highly correlated ($r = 0.87$). That is, external factors that increased or decreased bicycle traffic—weather, for example (Flynn et al., 2012)—did so uniformly across all routes. However, COVID-19 differs from other external factors in its differential effect on commuter and non-commuter routes (Fig. 8). From 2019 to 2020, commuter routes saw 89,093 fewer cyclists (28% reduction) while non-commuter routes saw 133,693 more cyclists (18% increase). This differential points to a change in bicyclist habits related to commuting.

3.3. Crash data

Crash rate. The number of bicycle injury crashes can be converted to an injury crash rate using the bicycle count data. Given that the counter numbers and locations remained static over the study period, these counts can be used to make conclusions about changes in bicycle crash rate over time. The locations of bicycle injury crashes involving motor vehicles in 2013–2020 are depicted in Fig. 9.

Because injury crashes were relatively rare, counts for 2013–2019 were combined to increase the stability of the comparison group. The data suggest that bicycle injury crash rates decreased in 2020 relative to the injury crash rates observed between 2013 and 2019: from an average of 2.74 per hundred thousand counts to just 1.98 crashes per hundred thousand (28% decrease; Fig. 10). Thus, the shift away from commuter activity and toward recreational off-road trail riding (described earlier) was accompanied by a reduced rate of injury crashes.

Time of day. We categorized injury crashes into morning, midday, and evening groups using the results from the finite mixture models for each calendar year. Matching the number of crashes against the number of bicycles counted for each time period allowed us to calculate injury crash rates for morning, midday, and evening. Consistent with past research (e.g., Kim et al., 2007), we found the morning period to be associated with the highest crash rate, both before the pandemic and during it. From 2013 to 2019, the morning crash rate was 3.1 per hundred thousand counts compared to midday and evening, which were both 2.6 per hundred thousand counts.

Fig. 7. Bicycle traffic counts from 2013 to 2020 for trails (left) and lanes (right) by rider type.

Fig. 8. Bicycle traffic from 2013 to 2020 for commuter and non-commuter routes, expressed as percent of 2013 traffic.
For 2020, the morning crash rate was 3.6 per hundred thousand counts, compared to 1.6 and 1.8 for midday and evening, respectively. Thus, the Arlington injury crash rate for mornings has consistently been higher than that for middays or evenings, and this differential grew in 2020 compared to past years.

Injury severity. Reduction in crash rates notwithstanding, average injury severity has remained relatively consistent since 2013, with 90–95% of injuries recorded every year being minor and without any fatalities reported. Injury severity in 2020 was similarly distributed. Thus, although riders in 2020 were 28% less likely to be involved in crashes with motor vehicles compared to 2013–2019, the severity of the crashes that did occur remained similar to that of past years (Table 1).

4. Discussion

The current study found that weekday bicycle traffic in Arlington County, VA increased sharply during the afternoon (+76%) between March and December of 2020, compared to the same period in 2019. The growth in overall afternoon bicycle traffic was mirrored by a reduction in morning traffic (−49%). However, the change in evening traffic depended upon the location of the bicycle counter. On-road lanes saw a 27% reduction in evening traffic, while multi-purpose trails saw a 6% increase. The degree to which routes experienced growth may be related to the degree to which those routes were involved with commuter traffic. From 2013 to 2019, traffic on the most popular commuter routes was highly correlated with traffic on more recreational routes, with weather and other external factors affecting both equally. In 2020, however, the most popular commuter routes saw a 28% reduction in ridership while more recreational routes saw a 18% increase in ridership compared to 2019. In sum, reduced overall mobility and changing commuter needs shifted bicycle traffic away from the long-held bimodal distribution observed from 2013 to 2019, which was defined by a pair of commuter peak in the morning and evening.

The change in 2020 bicycle traffic was associated with a 28% reduction in weekday bicycle-motor vehicle injury crash rate compared to past years. This trend is consistent with bicycle fatality data from the state at large: the 2020 calendar year saw 8 bicyclists killed by motor vehicles in Virginia, down from 13 the year before (−38%; Virginia DMV, 2021). A reduction in crash rate accompanying a shift away from morning cycling is consistent with our finding of an elevated injury crash rate among Arlington’s morning cyclists. Drivers are more likely to behave aggressively during the busy morning commute period compared to other times of day,
which increases the risk for bicyclists traveling alongside them (Eilert-Petersson and Schelp, 1997; Rodgers, 1995; Yan et al., 2011). Thus, the reduction in morning bicycle traffic observed in 2020 was likely a key contributor to the lower bicycle injury crash rate for 2020. The overall reduction in 2020 motor vehicle traffic may have also contributed to the lower bicycle injury crash rate observed in the current study. Fewer vehicles on the road translates to fewer opportunities for crashes between bicycles and vehicles. However, fatal vehicle crash rates increased in 2020 despite a reduction in vehicle miles traveled (National Highway Traffic Safety Administration, 2021), so it is not clear whether fewer vehicles on the road would be helpful or harmful with regard to bicycle crash injuries, particularly for severe cases.

Regardless of the effect that fewer (potentially faster-moving) vehicles had on bicycle crashes, it seems likely that Arlington injury crash rates decreased in 2020 because of the greater use of off-road trails. Multi-use trails are characterized by having few intersections with streets and limited exposure to vehicles. Although many types of facilities can improve rider safety over riding in the road (e.g., Teschke et al., 2012), increased physical separation between riders and motor vehicle traffic reduces opportunities for motor vehicle crashes. Some research has found that riders using off-road, multi-use trails are at the lowest risk of injury in a motor vehicle crash compared to riders using any other type of facility (Cicchino et al., 2020). Our data suggest that fewer riders counted during peak commuter hours—particularly in the morning—and a greater proportion of those riders using off-road trails are two likely mechanisms by which crash rates were reduced in 2020.

The bicycle represents a lifeline during the pandemic to satisfy distancing requirements while preserving a degree of mobility, both for basic travel and for exercise and recreation. News of COVID transmission on public transit in particular seems to have shifted preferences from group to solitary travel, especially in the early months of the pandemic (Teixeira and Lopes, 2020; Wang et al., 2021). Arlington is in a unique position because it already has a very well-developed network of lanes and trails (Hanson and Young, 2008). This infrastructure provides a convenient release for when people need or want to avoid other means of transportation. The off-road trails in particular were able to absorb a large amount of additional traffic (at least 300 more riders daily in 2020 compared to 2019) without increasing injury crash rates with motor vehicles. Cities with less well-developed infrastructure may not be able to accommodate such a shift, and new riders may instead choose to travel along routes where injury crash rates might not be so forgiving to additional traffic.

Governments and public health officials have suggested that cities make accommodations for non-motorized travel going forward, including closing streets to vehicle traffic so that bicycles and pedestrians can use them more safely (BCCDC 2020; Fischer and Winters, 2021; Government of British Columbia 2020). Expanding transportation options temporarily—or indeed, having a pre-existing network of off-road, multi-use trails—should be considered a “population health intervention,” a measure that reduce risks to health by making changes to the underlying environment (Hawe and Potvin, 2009). Research is clear that the provision of multi-use trails substantially increases the use of non-motorized methods for local travel (Ewing and Cervero, 2001; Frank et al., 2007; Hanson and Young, 2008). However, it will not always be practical to create new off-road trails, particularly in dense urban settings. In these cases, it should be noted that on-road lanes nonetheless carry safety benefits over unimproved areas (Cicchino et al., 2020; Hamann and Peek-Asa, 2013; Lusk et al., 2011; Marqués and Hernández-Herrador, 2017).

The bicycle counter stations in Arlington only record the number of bicycles that cross them. Because the counters are situated along the most popular routes, it is likely that the same bicyclist will have been counted by more than one counter per trip. Thus, any conclusions we have made about the bicycle count can only be understood as the number counted, not the number of unique bicyclists. The nature of repeated counts per unique bicyclist is consistent across the study period, though, and so inferences about change in traffic over time remain valid.

The current study tracked bicycle involved motor vehicle crashes that were reported to police. However, bicyclists get injured in other ways on off-road trails (e.g., falls, crashes with pedestrians and other cyclists), and those injuries are generally not reported to police. It is unclear what effect the change in ridership patterns observed in 2020 had on bicyclist injuries overall given the shift toward off-road riding. Nonetheless, the most serious injuries to bicyclists typically occur in crashes with motor vehicles (Chong et al., 2010), and so it is unlikely that the reduction in crashes between bicycles and motor vehicles observed in the current study was counter-balanced by an increase in unreported non-motor vehicle related crashes in terms of overall safety.

After COVID-19 is no longer a threat to public health, some employers may choose to continue expanded telework opportunities. Employees who previously commuted to work every day might switch to a part-time or full-time work from home schedule. Particularly as internet infrastructure continues to develop, pressure to maintain a physical presence in the office will likely diminish in years to come. A recent internal survey by the Bureau of Labor Statistics found that 90% of employees surveyed would prefer to return to the office no more than two days a week; 60% of employees preferred permanent teleworking (Bureau of Labor Statistics, 2021). Other employers may consider replacing crowded offices altogether with more automation. The net effect of such changes will be reduced numbers of individuals traveling for work purposes, which will mirror (in some respects) the state of affairs observed during the current pandemic period. Going forward, government officials ought to consider how off-road trails can provide a flexible avenue for

| Year | Fatal | Serious | Minor | Possible |
|------|-------|---------|-------|----------|
| 2013 | 0%    | 6%      | 86%   | 3%       |
| 2014 | 0%    | 3%      | 87%   | 0%       |
| 2015 | 0%    | 7%      | 85%   | 0%       |
| 2016 | 0%    | 4%      | 81%   | 7%       |
| 2017 | 0%    | 5%      | 74%   | 2%       |
| 2018 | 0%    | 3%      | 68%   | 0%       |
| 2019 | 0%    | 7%      | 72%   | 0%       |
| 2020 | 0%    | 4%      | 81%   | 2%       |

Table 1: Bicyclist injury severity distribution by calendar year.
residents’ changing transportation needs in the future.

The restrictions placed on travel that arose as a result of the COVID-19 pandemic served to motivate a shift toward bicycle travel. When the pandemic abates, however, individuals may no longer feel the same draw toward bicycling. Nonetheless, short-term increases in cycling use spurred on by necessity (i.e., because of COVID-19) might be capitalized upon by public health organizations to produce lasting change (Nielsen and Haustein, 2019). Depending on the locality in question, people who have added cycling to their daily routine might continue to travel in this fashion going forward. For example, the 2017 National Household Travel Survey estimated that the average vehicle trip length in the United States was about 10 miles (Federal Highway Administration, 2017). For denser urban environments especially, a transition from driving to bicycling might be quite practical given sufficient infrastructure.

Survey data suggest that American adults anticipate traveling by bicycle more often after COVID-19 is no longer a concern (Ehsani et al., 2021). The Arlington bicycle network originally gained popularity through a kind of positive feedback loop: a greater number of bicyclists created demand for better facilities, which in turn created political support to expand the network, which encouraged more bicyclists (Hanson and Young, 2008). The increase in ridership implied by the surge in new bicycle purchases and self-reported interest in bicycle travel during the COVID-19 pandemic may fuel a similar process elsewhere. Future research should monitor the popularity of bicycle travel in the years to come, with particular attention paid to changing crash rates as normal vehicle travel resumes. Sparse vehicle traffic likely contributed to the relatively low bicycle injury rates observed for 2020, so as vehicles return to the roads riders may be at increased risk for injury. Relatedly, crash rates for bicycle riders may increase if suitable infrastructure does not exist to convey them. Government entities that choose to promote active transportation bear a responsibility to provide the corresponding transportation infrastructure.

4.1. Summary

We found that COVID-19 and its associated lockdowns produced a dramatic shift in the amount and character of weekday bicycle travel in Arlington, VA. Across the board, traffic increased dramatically during the midday period and decreased in the morning. Evening travel increased for off-road multi-use trails and decreased for on-road lanes; these changes were associated with reductions in bicycle traffic along the most popular commuter routes. A shift away from commuter travel and toward off-road recreational travel had a favorable effect on crash risk, as riders in 2020 were 28% less likely to be involved in an injurious crash with a motor vehicle compared to the previous years. These findings point to the importance of available off-road multi-use trails in absorbing changes in travel behaviors without raising bicycle-motor vehicle injury crash risk.

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Samuel S. Monfort: Conceptualization, Methodology, Formal analysis, writing. Jessica B. Cicchino: Writing – review & editing. David Patton: Data curation, Conceptualization.

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