Boston University Initiative on Cities

BOSTON UNIVERSITY

Analyzing Transportation Safety in the Town of Arlington, MA

Urban Public Policy Lab
Prof. Justin de Benedictis-Kessner

METROBRIDGE

About this Report

This report is a product of student work in Boston University's Urban Public Policy Lab course taught by Prof. Justin de Benedictis-Kessner in Fall 2019.

Acknowledgments

The MetroBridge program at Boston University's Initiative on Cities wishes to thank our partners in the Town of Arlington for their collaboration and support on this project: Adam Chapdelaine, Arlington Town Manager; James Feeney, Interim Director of Facilities; Jennifer Raitt, Director of Planning and Community Development; and Daniel Amstutz, Senior Transportation Planner.

About BU MetroBridge

MetroBridge empowers students across Boston University to tackle urban issues, and at the same time, helps city leaders confront key challenges. MetroBridge connects with local governments to understand their priorities, and then collaborates with Boston University faculty to translate each city's unique needs into course projects. Students in undergraduate and graduate classes engage in city projects as class assignments while working directly with local government leaders during the semester. The goal of MetroBridge is to mutually benefit both the Boston University community and local governments by expanding access to experiential learning and by providing tailored support to under-resourced cities. MetroBridge is funded by the College of Arts and Sciences and housed at Boston University's Initiative on Cities.

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Executive Summary

The Town of Arlington approached Boston University's MetroBridge program with a policy and research challenge related to transportation safety planning. The town's streets are growing increasingly more crowded due to regional population growth, an increase of multi-modal users, and shifts in vehicular transportation, including the proliferation of ride share and e-commerce deliveries. At the same time, with a nationwide trend of increased traffic fatalities and injuries, traffic safety risks are a growing concern among Arlington residents. Arlington town officials are committed to developing a plan to provide safer transit options for all pedestrians, cyclists, and drivers.

The MetroBridge project for the Town of Arlington was designed to provide new analysis and related research to help guide future transportation policy and programmatic decisions. Students in Prof. Justin de Benedictis-Kessner's Urban Public Policy Lab class addressed this challenge by examining resident survey data, analyzing state and local transportation-related datasets, and visiting Arlington to observe transit behaviors.

The class divided into three teams of students, each focusing on a different aspect of transportation: 1) bicyclist safety 2) crashes involving vehicles and bicyclists along Massachusetts Avenue and 3) bus shelters. Each team prepared a report of key findings and recommendations for the Town of Arlington to consider. These suggestions include:

- Increasing visibility and establishing clear and permanent signage at vehicle intersections along the Minuteman Commuter Bikeway
- Widening the pavement along the Bikeway and adding additional amenities (restrooms, benches, etc.)
- Expanding approaches for collecting and sharing data on traffic complaints and traffic crashes to allow for more precise and rigorous analysis
- Enhancing cyclist safety through improvements to bike lane infrastructure
- Improving the town's bus shelters to provide more widespread and equitable access to safe, protected areas to wait for the bus

The students' research, findings, and recommendations are discussed in more detail in the following report prepared for the Town of Arlington.

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Team 1

Data Analysis and Policy Recommendations: Cycling in the Town of Arlington

Metrobridge Final Assignment

Urban Public Policy Lab

Caitlyn Ackerman, Sarah Burrola, and Alejandro Camarena

I. Background

The town of Arlington is a hub of bicycle traffic, both for residents of the town and commuters who make use of the town's bike amenities–most notably, the Minuteman Commuter Bikeway. Despite the popularity of biking in and through Arlington, a survey of town residents found that only 5% of respondents currently cycle as their primary transportation. Our research question, then, is: why aren't more residents of Arlington cycling, and how can the Town address this?

Our analysis found that 30% of respondents in the town survey indicated that they would prefer to bike, but factors such as safety prevented them from doing so. Our research makes use of observations and the data available to us to determine areas and characteristics of Arlington that may threaten the (real or perceived) safety of cyclists. Our analysis and results will accordingly most greatly affect residential and commuter bicyclists in the Town of Arlington. However, our suggestions for improvement (which include encouraging cyclists who are able to switch from cycling on Massachusetts Avenue to the parallel Bikeway) will also improve experiences on the road for the vehicles, pedestrians, and other groups with whom bicyclists interact. In sum, we demonstrate via our data analyses that the Minuteman Commuter Bikeway is a safe bicycling option for residents and commuters, and is a viable alternative to mixed-vehicle routes, such as Massachusetts Avenue. We also employ site observations to surmise why bicyclists may not prefer to travel on the Bikeway, or why survey respondents indicated safety as a deterrence to cycling. These results are then used to offer possible policy amendments that would encourage greater use of the Bikeway and of cycling generally.

II. Data

In performing our analyses, we made use of the following datasets: Arlington town surveys; the "Arlington Roads" data; LimeBike data and commute data; MassDOT crash data specific to the town of Arlington; and Arlington traffic complaint data. These data were collected in various ways. The MassDOT crash data consists of a state-facilitated report of every reported automobile crash in the Commonwealth of Massachusetts between September 2015 and September 2019. Parameters of the crash data include the location, time, and type of crash. The complaint data were collected by the town of Arlington and consist of citizen-reported traffic complaints from the last decade (2009 to 2019). The Limebike data were collected per quarter year during 2018-2019, and reflect usage of the dockless Lime Bikes in the Metro Boston area by measuring the total number of trips taken by Limebike users along segments of roads and major pathways in Boston.

The data we've chosen to analyze primarily reflect the experience of cyclists–both locals and commuters–as well as pedestrians and drivers who encounter them. Considering Arlington consists of a significant biking community, we'd like to think these data are fairly representative of the community. However, we also acknowledge that many cyclists come from adjacent communities, and that some residents may never interact with cyclists (i.e. the homebound, pedestrians who walk primarily in pedestrian areas, etc.) Nonetheless, we are comfortable asserting that all Arlington residents hope for the safety of their fellow residents who bike or for nonresidents who make use of Arlington's extensive bike paths. Thus, while our data may not reflect the experience of every Arlington citizen, our analyses and resulting conclusions and suggestions would impact every resident.

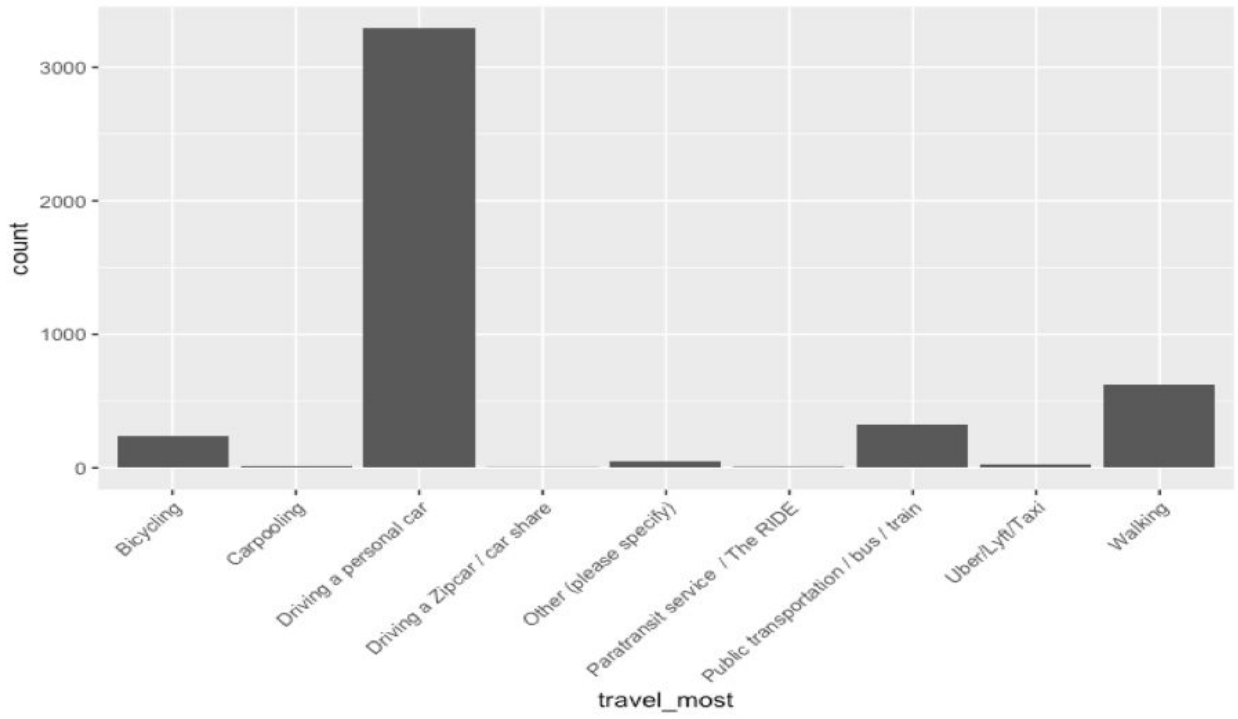
Since the data available to us left some things to be desired, our variables are rough approximations of concepts in the world, but can certainly be improved upon. For example, the "location" variable in the complaints dataset was no more specific than a general street name. This is a poor representation of traffic complaints, as the variable would ideally represent more specific phenomena

(like a certain intersection, stretch of road, driveway, etc.) that produce complaints. The LimeBike data was, in particular, problematic in the ambiguity of traffic distinctions amongst the different pathways–for example, while you can see the distance of each segment and the total number of trips per segment, there is no way to define start and end points, given that Lime bikes operate on a dockless system. Furthermore, the LimeBike data only reflects a small portion of bike users in the area, and is not fully representative of all bike commuters in Boston or Arlington in particular.

One substantial data manipulation we performed was narrowing down the MassDOT crash and Arlington complaint data to only the topics and areas with which we were concerned. For the crash data, that meant creating a new dataset of only the incidents involving bicycles; for both the crash and complaint data, this meant identifying the locations we're studying–namely, Massachusetts Avenue, the Commuter Bikeway, and the roads with which each intersects. These locations were chosen because of their popularity among bicyclists. Massachusetts Avenue is a major route, and our analyses demonstrate that it is commonly traveled by cyclists despite running parallel to the automobile-free Bikeway.

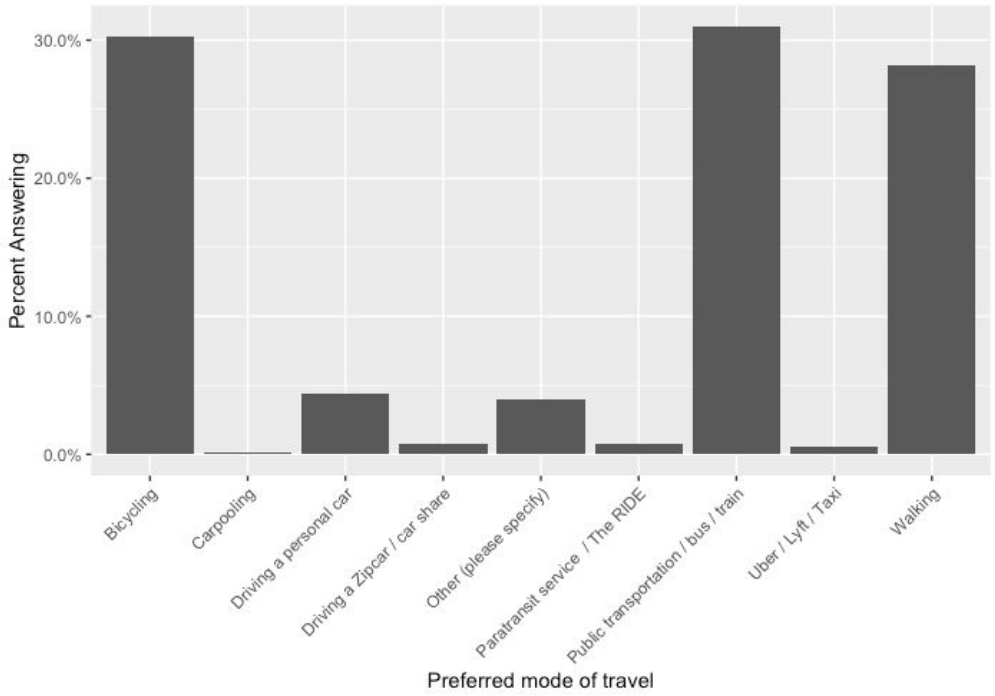
It is also important to understand why bicycle safety matters in Arlington— for this we took an in-depth look at the 2019 Town Survey conducted in Arlington. With only about 4,500 respondents in a city with a population of roughly 42,000 in 2010, this data and the conclusion drawn around it should not be taken as definitive or holistic in any sense—this analysis serves as the start of what would require significantly more data and resources to truly understand the trends in bicycling and safety within Arlington. With that said, we begin by taking a look at the responses given by respondents with regard to preferred method of travel.

Figure 1:



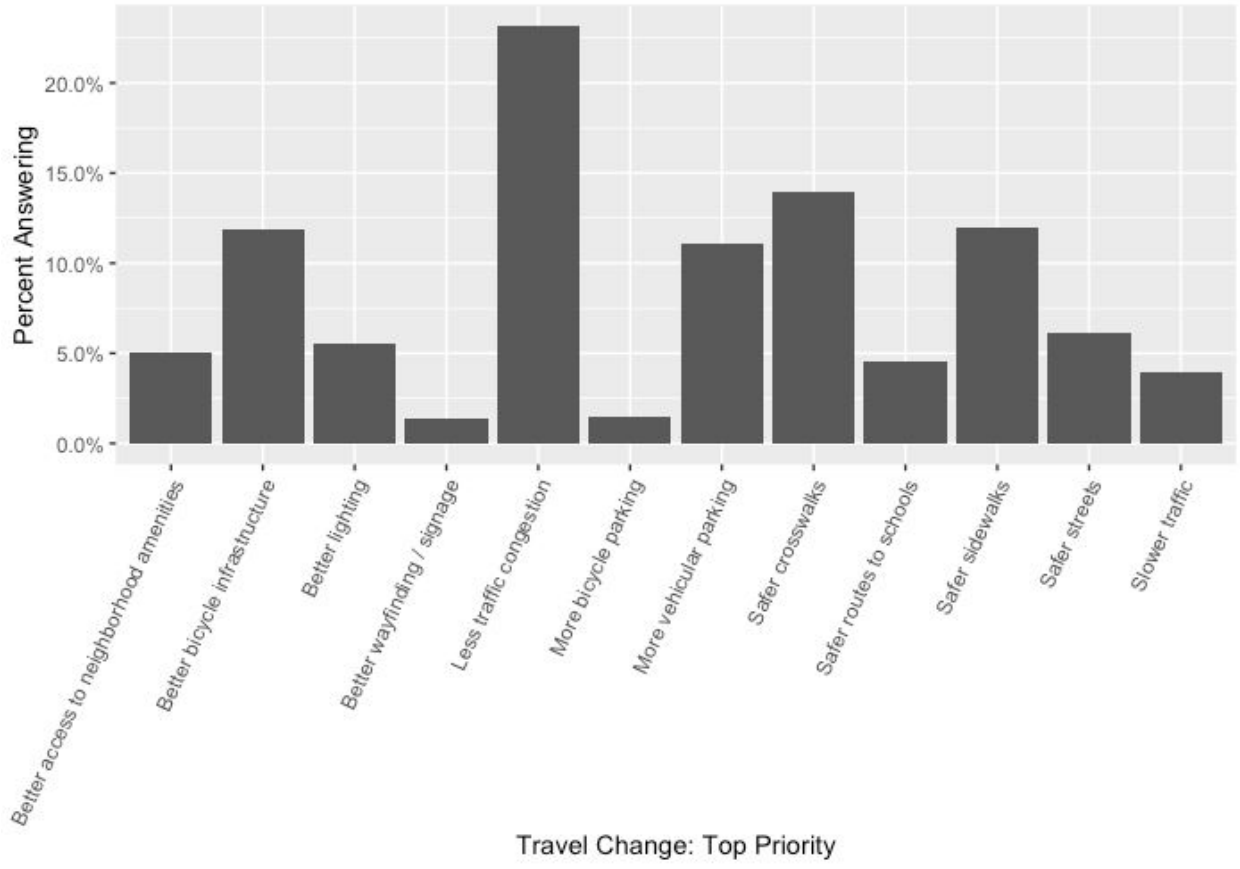
Looking at the graph above, the x-axis represents the mode of transportation used most by respondents and the y-axis represents the amount of respondents who chose them. The most prominent bar on this graph belongs to the percentage of respondents who cited “Driving a personal car” as their most used form of transportation in Arlington, roughly 73% of respondents. On the left most portion of the graph we can see that roughly 5% of respondents cited “Bicycling” as their most used form of transportation. We chose these two variables to focus our attention on because the data regarding the Preferred Method of Transportation, as opposed to the Most Used Form of Transportation in Figure A, highlights an important trend regarding transportation on Arlington.

Figure 2:



Firstly, in regard to the graph in Figure B, the x-axis represents the preferred method of transportation in Arlington, and the y-axis represents the percent of respondents who chose them. In analyzing this graph, we realized that there is an interesting relationship between the preferred method of transportation and the most used form of transportation. While roughly 73% of respondents cited driving as their most used form of travel only about 9% cited it as their preferred method of travel. This, as opposed to in bicycling, where only about 5% of respondents cited it as their most used form of travel but 30% cited it as their preferred method of travel. With that in mind we decided to look at what people in Arlington felt should be made a priority with regard to what should be changed about transportation in the town.

Figure 3:



In this graph, the x-axis represents what respondents feel should be made a priority with regard to what needs to be changed about travel in Arlington, the y-axis the percent of respondents who chose a given option. Naturally, with so many drivers, the biggest issue seems to be traffic congestion—roughly 23% of respondents feel that this should be made a priority. As for bicycle infrastructure, about 12% of respondents feel this should be made a priority. So why prioritize bicycle safety? My group hypothesized that, when we combine the two percentages, that being 35% of respondents, we see that the biggest issues in Arlington can be solved by improving bicycle safety. With that in mind, we proceeded to look at the

barriers to cycling to conclude whether or not improving bicycle infrastructure could be connected to bicycle safety.

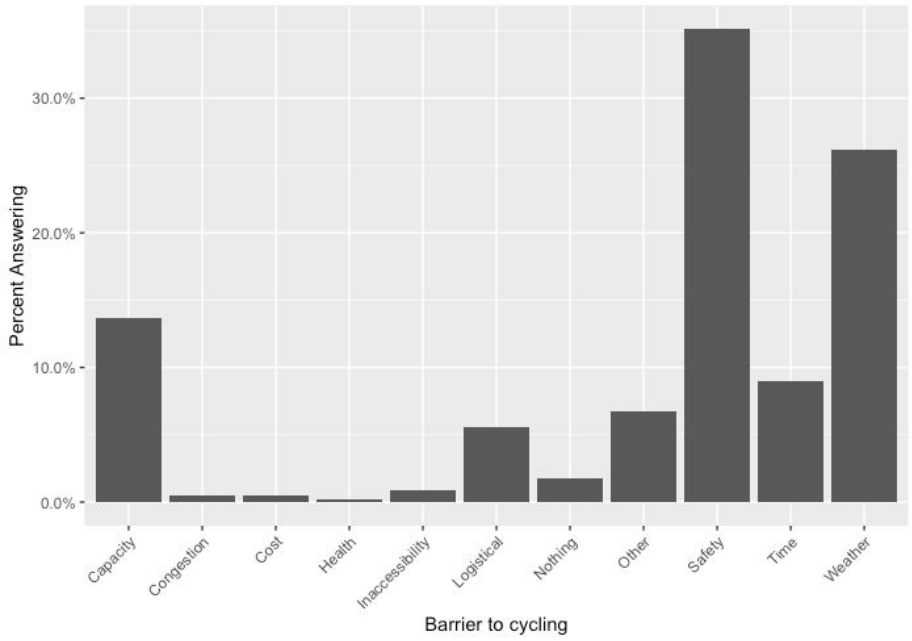


Figure 4:

On this graph, the x-axis represents the barrier to cycling and the y-axis represents the percentage of people who chose each. Examining this graph, we can indeed see that about 31% of cyclists feel safety is the greatest barrier to cycling. This is followed closely by the weather, which is beyond the control of the city of Arlington.

III. Results

We conducted several analyses on our data in order to better understand the traffic and problem areas of Arlington. One such analysis involved creating a new dataset from the MassDOT crash data of

only those crashes involving bicycles, and then analyzing where these occurred. Partial results of this are depicted in Figures 5 and 6.

Figure 5:

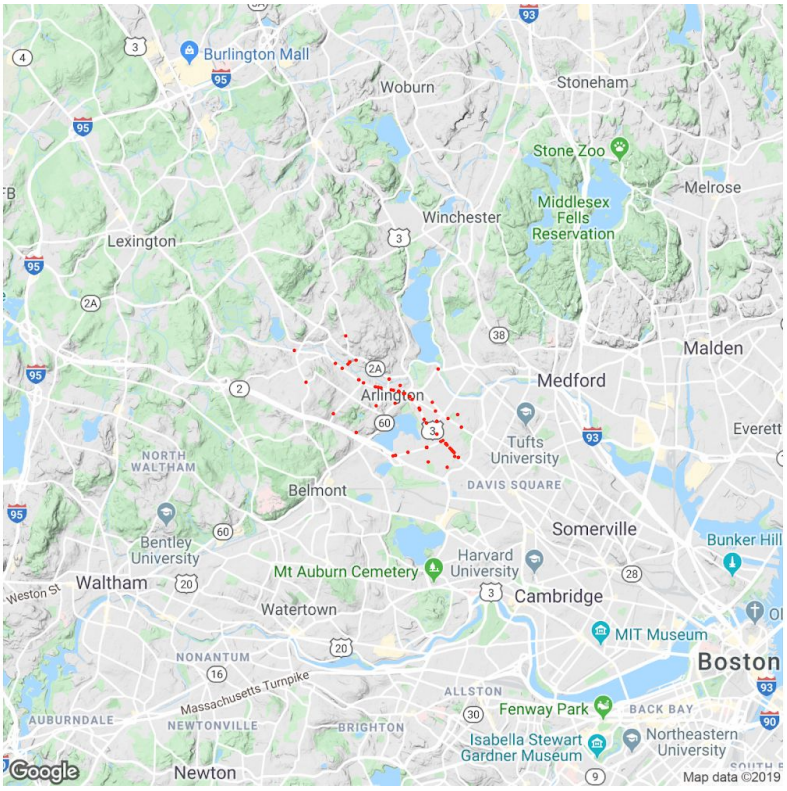


Figure 1 is representative of each automobile crash, as gleaned from the MassDOT crash dataset, that involved a bicycle. From September 2015 to September 2019, there were 70 such crashes in Arlington. Each red dot on this map represents one of these crashes; most notably, the majority of these crashes occurred along Massachusetts Avenue (labeled as Route 3 in Figure 1). Over this four year period, 38 crashes involving a cyclist happened either along a stretch of, or at an intersection with, Massachusetts Avenue.

Figure 6:

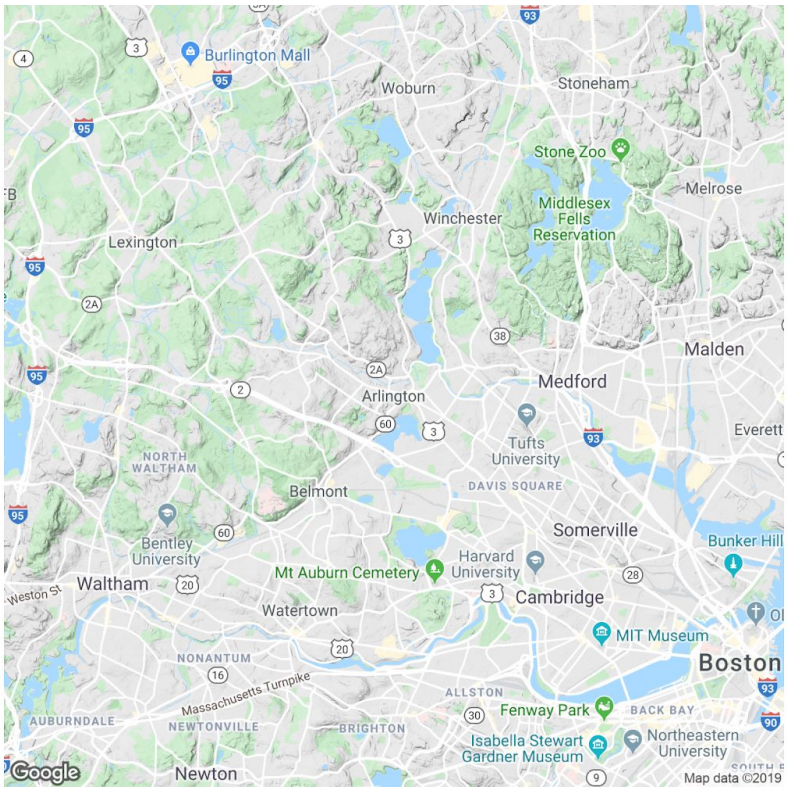


Figure 6, meanwhile, depicts just the automobile crashes involving bicyclists along Bikeway. Obviously, as there are no automobiles allowed on the Bikeway, there are no such crashes here; however, there are notably also no crashes at *intersections* where bicyclists on the Bikeway would encounter vehicle roadways. Although the visualizations speak for themselves, a t-test conducted on the average number of yearly bicycle crashes (about 7.5/year for Massachusetts Avenue and 0/year for the Bikeway) found that the difference is extremely statistically significant ($p < 0.0001$). By the metric of crashes, then, the Bikeway is a much safer route for bicyclists than Massachusetts Avenue.

The metric of complaints, however, might tell a different story of safety. Between 2009 and 2019, 28 complaints regarding the Bikeway were reported. With no way to know where or why these complaints were filed, it is uncertain if these reasons are deterring bicyclists from cycling on the Bikeway or in Arlington more generally.

Via our site observations, we identified some reasons why Arlington residents may choose to cycle on Massachusetts Avenue rather than the Bikeway, or not cycle at all. One such reason deals with perception of safety. Although our primary measure of safety (crashes) gives one narrative of relative safety, perception (and possibly the complaints data) might offer another. For example, we observed that although Massachusetts Avenue is a mixed-vehicle road, it has designated bike lanes along much of it. Additionally, the rules of right-of-way may be clearer there than along the Bikeway, since bicyclists are ostensibly meant to follow the same traffic light rules as automobiles. Both of these factors may contribute to greater convenience and clarity. Meanwhile, although the Bikeway is reserved for bicyclists and pedestrians, the intersections at which bicyclists must interact with vehicles on perpendicular roads may pose a greater threat than if the cyclist were to simply travel with automobiles down Massachusetts Avenue. One such intersection we observed was that of the Bikeway and Lake Street (Figure 7).

Figure 7:

The rules at this intersection are unclear; drivers must stop for pedestrians–but not necessarily bicyclists–at the crosswalk, while bicyclists must stop at the stop sign (pictured on the left of Figure 3) which is itself occluded from drivers by tree branches. Additionally, there is currently no signage indicating to drivers that bicyclists may be crossing. These infrastructure oversights may certainly be to blame for the bike path complaints and the residents who cite safety as a deterrent to biking regularly.

IV. Proposed Reforms

The Town of Arlington has done a remarkable thus far of prioritizing bicyclists and their safety. One such example of this is the Town's plan to install a traffic signal at the intersection of Lake Street and the Bikeway, an intersection that, as we noted, could certainly benefit from clearer rules. However, there are additional reforms that we suggest could improve the experience of bicyclists in Arlington even more.

One such change is simply better collection and management of data. The analyses we were able to perform with the data as they are currently were undoubtedly helpful, but not necessarily conclusive. Specifically, more comprehensive complaints data (i.e., including location and reason for complaint) could exhibit a pattern indicating the most problematic aspects of the Bikeway for bicyclists. A result such as that would certainly impact our recommendations for proposed reforms.

Our most significant proposals invoke the conclusions of the Arlington Biking Advisory Committee's 2014 report. Our analyses and anecdotal observations back up the suggestions of this report; we strongly recommend prioritizing intersections of vehicle roadways with the Bikeway. Specific amendments may include cutting back on foliage in order to increase visibility, and establishing clear and permanent signage.

Lastly, an important consideration if the Town is successful in encouraging significantly more residents to use the Bikeway (either recreationally or for commuting) is to ensure the Bikeway is prepared to accommodate increasing ridership. These adjustments would be more costly than our previous

recommendations, and include widening the pavement of the Bikeway and introducing additional amenities (restrooms, benches, etc.) to the path. Nonetheless, they are certainly worth considering once current barriers to more regular cycling (such as perceptions of safety) are dismantled.

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Team 2

Final Research Report
PO520 Final Metrobridge Project
Carter Farnsworth, Jared Flippen, Samantha Feigelson

Background

For our project, we studied bike safety in Arlington. Specifically, we studied the correlation between crash probability and bike lane presence in front of driveways on Massachusetts Avenue. Using Google Maps Street View, we mapped everywhere from 1 Massachusetts Avenue to 1034 Massachusetts Avenue where there was a driveway from a residence or commercial area that pulls out onto Mass Ave. We then also took note of where there was also a bike lane and/or parallel parking. (as demonstrated in figure 1). We focused on these specific road conditions after our site visit on 11/13 to Central Arlington revealed a few pretty severe safety concerns presented by these conditions. Even without added distractions, cars pulling out of driveways onto Massachusetts Avenue force bikers to either increase or decrease their speed in order to let a vehicle pull out. This forced decision for bikers becomes even more dangerous when the driveway is accompanied by parallel parking on either side, reducing the physical room available to bikers and significantly diminishing the biker's room for error. The danger presented by this situation is compounded upon by the variance of bike lane appearance throughout Massachusetts Avenue in Central Arlington. Notably, even when there is a bike lane present, the bike lane is unprotected.

Figure 1

Figure 1 is at 699 Mass Ave. in Arlington's downton. As the picture demonstrates, there is a lot going on here. There is a car pulling out of a parking lot, traffic on Mass Ave, cars that are parallel parked, and no bike lane.

Another reason we focused on bike safety is it addressed a few clear priorities for citizens of Arlington in their town survey. The clearest takeaway from the 2019 survey was that people in Arlington were not happy with their current mode of transportation. These unhappy commuters wanted more than anything to reduce traffic congestion, as they believed it was the primary obstacle to their ability to change modes of transport. Of that same group of unhappy commuters, 30% said they would rather bike around Arlington than use their current mode of transportation, and those would-be bikers said their number one concern was safety, or a lack thereof. This, paired with the fact that the number four concern four unhappy commuters was improved bike

infrastructure, regardless of their preferred mode of transportation, convinced us that our efforts should be concentrated on

Data

Using Google Maps, we geocoded everywhere from 1 Massachusetts Avenue to 1034 Massachusetts Avenue in Arlington, MA where there was a driveway that pulled out onto the street. We then recorded whether there was parallel parking and/or a bike lane in front of the driveway and recorded the address.

We then drew a 50 meter circumference around each driveway so that we could compare crashes that occured within the radius of the driveway. As discussed later, 50 meters was largely an arbitrary measure but we felt it was a sufficient estimate of the effect a driveway could have on a crash. A crash that is caused by traffic in front of the driveway might not happen exactly in front of the driveway, but about 25 meters before or after the driveway. Finally, we divided driveways between

We then compared our driveway data with crash data supplied by the Massachusetts Department of Transportation that recorded every crash that happened in Arlington from 2015 to 2019. The dataset includes many variables, but we focused on location and who was involved in the crash (cars, cyclists, pedestrians). Unfortunately, about 50% of the crashes in the dataset could not be included in our analysis because the crashes did not include street numbers that corresponded to where the crashes occurred. Entries would only say “Massachusetts Avenue” or “Mystic Street” but wouldn’t give a street number so we couldn’t determine where along those

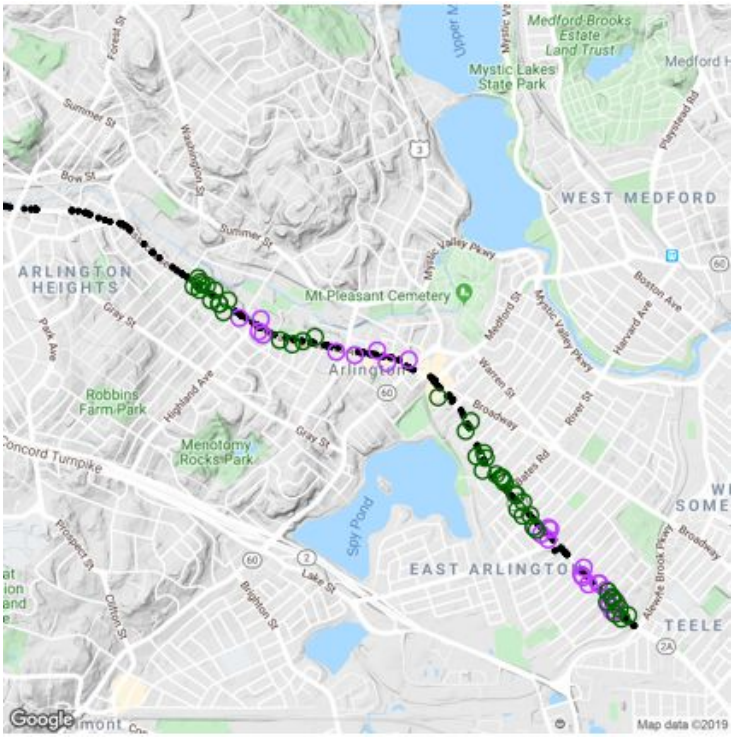
streets the crash occurred. Unfortunately those data had to be emitted from the research. Future analysis should seek to remedy this problem.

Results

We found insufficient evidence to prove that the presence of a bike lane affected the probability of their being a crash in front of a driveway. Driveways that did have a bike lane in front of it had statistically similar crashes to driveways that had no bike lane.

	t-value	p value
All Crashes	1.0229	.3112
Pedestrian and Cyclist Crashes	1.5402	.1420

After conducting a two tailed t-test we found both values to be statistically insignificant, even when we subsetted the crash data to only include crashes that involved pedestrians and cyclists. Both p values exceeded .05, the conventional cut off point needed for a value to be considered statistically significant.



The map to the right shows a visual representation of our results. The black dots represent every crash that happened along Mass Ave from 2015 to 2019. Green circles represent the 50 meter circumference around driveways that did have a bike lane in front of it and purple circles represent places that did not

have a bike lane in front of it. Using this map, we compared the mean number of crashes in driveways with no bike lane to driveways with a bike lane and found the difference in crashes to be statistically insignificant (p=.3112).

These results proved surprising and there are numerous considerations before making any conclusions. Namely, the circumference we drew of 50 meters was largely arbitrary. Different results may occur of the size of the radius is changed. It is difficult to measure what the potential "sphere of influence" is around a driveway where the traffic it causes could cause a crash. Future research could adjust the circumference to conduct new tests.

Additionally, over 50% of crashes in the original dataset provided by the Massachusetts Department of Transportation is not included in this research because there was not about information about the location of the crash. For many entries only a street name would be recorded, but nut a street number, so we were unable to record exactly where the crash occurred. If these crashes were included in our analysis, our results could change dramatically. Figuring out ways to uniformize the way that crashes and complaints in Arlington are recorded should a priroirty for the town to improve the quality of future data analysis.

Proposed Reform

Our analysis found that the presence of a bike lane did not greatly impact the probability of their being a crash in front of a driveway. If this is the case, then something needs to be done to improve the effectiveness of bike lanes in Arlington. Recognizing Arlington's goal to increase transportation safety while remaining within a strict budget, we derived a policy plan. Our preferred option, due to its inexpensive and realistic nature, outlines a plan for Arlington to add

green bike lane pavement in front of Massachusetts Avenue driveways. According to the National Association of City Transportation Officials (NACTO)[1], colored pavement increases visibility, identifies areas of conflict and reinforces priority to bicyclist in conflict areas. Due to the parallel parking in front of these driveways, drivers are subject to blind spots and cannot correctly identify a biker within a given radius. These recurring instances along Massachusetts Avenue can be classified as possible areas of conflict, allowing this project to be fully compliant with the intended use of the pavement.

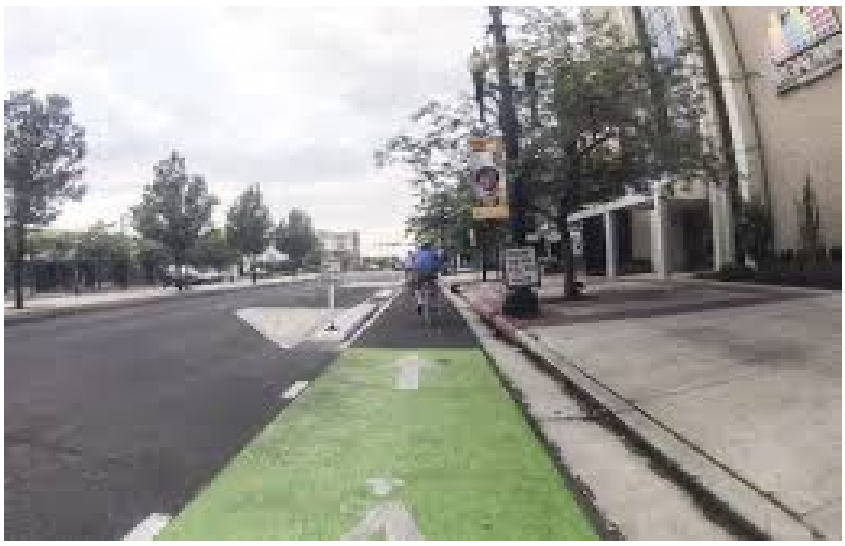


Figure 3

Figure 3 illustrates our policy plan. To the right, there is a driveway. In front of that driveway is green pavement to identify a bicycle lane and signal to drivers, allowing them to be more attentive and cautious before making a right or left.

[1] Ink, Social. "Colored Bike Facilities." National Association of City Transportation Officials, July 24, 2015. https://nacto.org/publication/urban-bikeway-design-guide/bikeway-signing-marking/colored-bike-facilities/.

The monetary cost of this project would be between $22-$600 per unit[2], according to Pedestrian and Bicycle Information Center. It is important, however, to note the center did not specify the exact measurement of a unit.

In addition to the bike pavement, Arlington should enforce town wide informational campaigns aimed towards all residents and commuters. Arlington can implement this is by using social media, such as Twitter and Facebook, hosting town halls, creating a town wide transportation safety newsletter via print or email, and hosting driver and biker education courses. This extra layer is effective and relatively cheap.

Our second policy option is to install protected bike lanes along Massachusetts Avenue. Although this policy is costly, it is more effective due to its physical and permanent barrier, separating cars from bikes.

[2] "Cost for Pedestrian and Bicyclist Infrastructure Improvements."Pedestrian and Cyclists Information Center. October, 2013. http://www.pedbikeinfo.org/cms/downloads/Countermeasure%20Costs_Report_Nov2013.pdf

As shown in the figure above, and described earlier, protected bike lanes create a physical barrier between cars and bicyclists. This policy option is more structured, and relies less on human judgement and perception. This has been researched heavily and there is data to prove its effectiveness.

According to the New York City Department of Transportation[3], protected bike lanes lead to over 50% reduction in injuries. As seen in New York, Washington D.C., and other big cities[4], there is evidence that protected bike lanes encourage biking, leading to a decrease in pollution and traffic. Considering the commercial nature of Massachusetts Avenue, there is also sizable evidence suggesting protected bike lanes hold economic benefits by boosting business performance[5]. Not only can these protected bike lanes decrease pollution and congestion, promote biking, and increase safety, they will also help Arlington's business owners.

However, this policy option comes with a significant implementation cost. Protected bike lanes cost between $133,170 and $536,680 per mile[6] and the Town of Arlington has a tight budget, meaning this may not be immediately plausible. Additionally, this policy has to be done in a timeline that considers all other projects done in the town, to ensure these projects don't conflict and present additional safety problems. As evidenced by the protected bike lane project done on Commonwealth Avenue on BU campus, significant construction near the protected bike

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[3] "Statistics Category • PeopleForBikes." PeopleForBikes. http://peopleforbikes.org/our-work/statistics/statistics-category/?cat=protected-bike-lane-statistics.

[4] Ibid

[5] Ibid

[6] "Cost for Pedestrian and Bicyclist Infrastructure Improvements." Pedestrian and Bicycle Information center.http://www.pedbikeinfo.org/cms/downloads/Countermeasure_Costs_Summary_Oct2013.pdf

lanes can put both pedestrians and cyclists in danger. Since we recognize the expense and time necessitated by this project, we consider this policy to be a long term possibility.

Conclusion

The absence of a correlation between bike lanes and preventing crashes shows that current bike lanes are not effective or safer than areas without a bike lane. With this data, we are left with a twofold conclusion. First, Arlington must improve their data collection process for crash tracking. Currently, over half of reported crashes do not contain an exact address, thus a statistical analysis can only be done with under half of the reported crashes. Arlington, by requiring an exact street address, will enable future data analysis to be more precise and representative of current phenomena. Lastly, as our two policy options suggest, existing bike lanes in Arlington must be improved. As mentioned previously, improving bike safety address specific concerns from the citizens of Arlington as well, like reducing traffic congestion and improving bike infrastructure, allowing more people to bike rather than drive around Arlington. In order to address public concern and improve safety townwide, Arlington should focus on these policy options to improve bike safety, as well as improve their data collection process to ensure a more thorough data analysis in the future.

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Team 3

A Boston University MetroBridge Project in Partnership with Arlington, MA

Arlington Bus Shelter Initiative

CAS PO-520

Nicole Arenth
Alexandra Bertrán
Michael Caulfield

Our team, via the BU MetroBridge Project, focused on addressing some of the concerns that the leadership of the Town of Arlington brought to our attention. Congestion and increasing vehicle traffic are an issue in the Greater Boston Area. We sought to create solutions through public transportation and developing a better transit balance within the community. Improving travel safety, reducing travel time, and increasing satisfaction are important priorities for Town residents and leaders. We researched what improving transit through low-cost measures might look like in this community. We discovered opportunities for redesigning partnerships with the MBTA to expand the number of bus stops with improved amenities, including adding new accessible bus shelters. We used several datasets to develop policy recommendations focused on adding benefits while considering economic efficiency. Though Arlington is a wealthy town which could choose to make significant investments to improve its infrastructure, we recommend an opportunity for Arlington to make improvements without shouldering the entire capital cost through a potential new strategic partnership agreement with the MBTA. The ultimate aim is improving accessibility of more sidewalks and bus stops in Arlington, and to notify Arlington of this potential opportunity to develop a self-perpetuating advertising revenue stream that may help to offset their maintenance costs of ADA improvements and bus stop amenities.

Our literature review included research focused on increasing mass transit ridership as a measure to decrease overall vehicle traffic and congestion over time, impacts of bus stop amenities, and metrics for evaluating great places to live. Our research and policy recommendations are: for Arlington to focus on negotiating a partnership with the Massachusetts Bay Transportation Authority (MBTA) to make requisition requests for more bus shelters to be

placed at strategic stops in Town. This report includes our background research, outcomes and recommendations, as well as areas for further research and analysis so that Arlington may continue improving as a growing Boston suburb offering its residents a high quality of life and opportunities to develop strong ties to the community.

Existing Transit in Arlington, MA

Close proximity to the MBTA Red Line at Alewife Station and ten bus lines are a benefit for residents seeking to travel to Cambridge, Boston and beyond without having to worry about driving, parking and dealing with city traffic to get where they want to go. Three of the bus lines travel through East Arlington and directly benefit from the dedicated morning rush hour bus lane. Striking a balance of personal vehicles and busses to take more people where they want to go in less time, and with less stress, is a constant challenge. By improving the amenities at bus stops and thus increasing ridership on the 77, 79, and 350 bus lines, and others, Arlington can continue to enact changes in the short term that will benefit the growing Town in ways that will add benefit over the upcoming decades by reducing car congestion.

Background

In February 2019, Boston topped the list of U.S. metropolitan areas for traffic congestion during rush hour. The 2018 INRIX study we reviewed measures commutes in terms of minutes rather than miles, which is a fair assessment of an aspect of quality of life that Arlington's leadership hopes to improve for its residents and visitors. According to the INRIX study's updated metrics, the average driver in the Greater Boston Area lost 164 hours in one year due to congestion, moving the city from seventh in the U.S. to first, using the 2017 data (INRIX, 2019).

Clearly, increasing vehicle traffic is a major issue in the Greater Boston Area and the goal to improve travel safety and efficiency for people living in and traveling to Arlington, MA is an

important priority. Town leadership have communicated their commitment to maintaining and improving Arlington's identity as a Boston suburb offering high quality of life to residents despite recent increases in population density and traffic congestion. Therefore, it is imperative that we support the Town's continuing change by making policy recommendations with strategic planning in mind to improve quality of life for Town residents. A particularly useful article notes that the MBTA's Director of Revenue, Evan Rowe is aware that the current "amenities often don't meet our customer needs" and that MBTA leaders are seeking to change the structure of contracts that the T uses to engage outside companies who manage bus shelters (Lisinski). Under the recently suggested design, the MBTA would cover the capital cost of bus shelters and the third-party companies would be responsible for all operational costs and maintenance. The MBTA contract with JCDecaux, which manages and maintains many bus shelters throughout the transit system, is up in 2020. This means that Arlington has the opportunity to make informed, strategic changes to the face and function of Arlington's sidewalks and bus stops in ways that are mutually beneficial to residents of the Town and to the MBTA. Bringing bus stops up to ADA compliance benefits all riders using those stops. And installing shelters that provide seating and protection from the elements is linked to increasing ridership (Kim et al., 2018). This policy recommendation unites bringing more sidewalks and bus stops up to code with the Americans with Disabilities Act, while making walkable bus stops more appealing to residents who may not already use mass transit.

Data

For this project, we focused on data from the 2018 and 2019 Arlington Town Surveys, the 2015-17 MBTA Systemwide Survey, The Environmental Justice Viewer for the Commonwealth of Massachusetts, and 2018 Bus Boardings to conduct our research. The MBTA

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Systemwide data from 2015-2017 was collected by administering lengthy and detailed surveys to MBTA System riders and sorting the data by transit line (2015-17). We used these data to inspect variables informing us on the demographics of riders by bus line as well as accessibility ratings of bus stops. We looked into percentage of riders who walk or bike to their stops, proportions of riders with alternate modes of transit, percentage of non-White riders, and people using reduced fare cards. We also graphed the accessibility ratings of the 160 bus stops in Arlington, as seen in Figures 5 and 6, to analyze how we could factor accessibility into our recommendations. Originally the wheelchair accessibility was coded with the variables "0", "1", and "2". We recoded this in order to match up with the actual meanings. We made 0 equal "minor accessibility barriers", 1 "moderate accessibility barriers", and 2 "significant accessibility barriers". Accessibility barriers include things such as obstructions that can create an inability for an individual in a wheeled mobility device to board the bus at the stop and may require that the bus operator to go to another spot on the sidewalk to board the passenger. Thus, this dataset allowed us to look into riders that we believe will be more transit dependent and would benefit from more comfortable bus stop amenities while also considering the need for accessibility and equity prioritization.

We analyzed the MBTA Boarding data to inspect bus stops by average boardings, sidewalk condition, accessibility compliance and ratings, and existence of shelters. In order to view the bus boardings data for Arlington, we filtered the data to only include Arlington. We used the bus stop data to overlay the bus stops, boardings, and existing shelters onto a map of Arlington, MA.. Out of all of the bus stops that the MBTA serves, approximately 10% have both a shelter and a bench (Bus Stops and Amenities). Arlington has 160 bus stops and merely ten bus shelters, and the Town is underrepresented in regard to bus stop amenities.

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The 2019 Arlington Town Survey was useful to better understand how transportation impacts Town residents and reviewed the open-ended responses to better understand the ways residents want it to change. The data from Figures 1 and 2 were created using data from the 2019 Arlington Town Survey conducted by the Town of Arlington. The Town surveys were sent to all households comprising Arlington's 45,000 residents and about 4,500, equivalent to roughly 10% of Arlington's residents, responded. Despite this sample not representing the entire population, we use the survey to get a better understanding of what some of the more vocal stakeholders want and what the larger population could potentially benefit from.

Additional data reviewed for foundational understanding of the Town, its residents, and amenities include Environmental Justice Census block data. The Commonwealth of Massachusetts collated these data using their guidelines for Environmental Justice, making this an excellent resource for researching equity. It was important to create a strong foundational knowledge with varied data sources, as no one resource can tell us the whole story. Table 1 further discusses some of the benefits and drawbacks of these datasets.

Table 1
Datasets: Benefits and Gaps

DATASET	BENEFITS	GAPS/DRAWBACKS
Arlington Town Survey 2018, 2019	What residents do and whether in or outside Town, what residents want, demographic data	Redacted for privacy so, no intersection-level or address-level access
2015-17 MBTA Systemwide Passenger Survey	Complete line data by bus routes with demographic data and purpose for trips	Lacks definitive information on where riders of particular lines live or originate travel
Environmental Justice Viewer (2010)	Provides census data on block level with layers including population 25% and above non-White, English language isolation, and household income at or below 65% of state median ($62,072 in 2010)	Great overall, but data is now nearly 10 years old and the map layer is by block group so cannot be exact to measure bus stop proximity
2018 Bus Boarding	Line and stop level detail, accessibility and wheelchair data, boardings	Accessibility boarding data is likely less complete

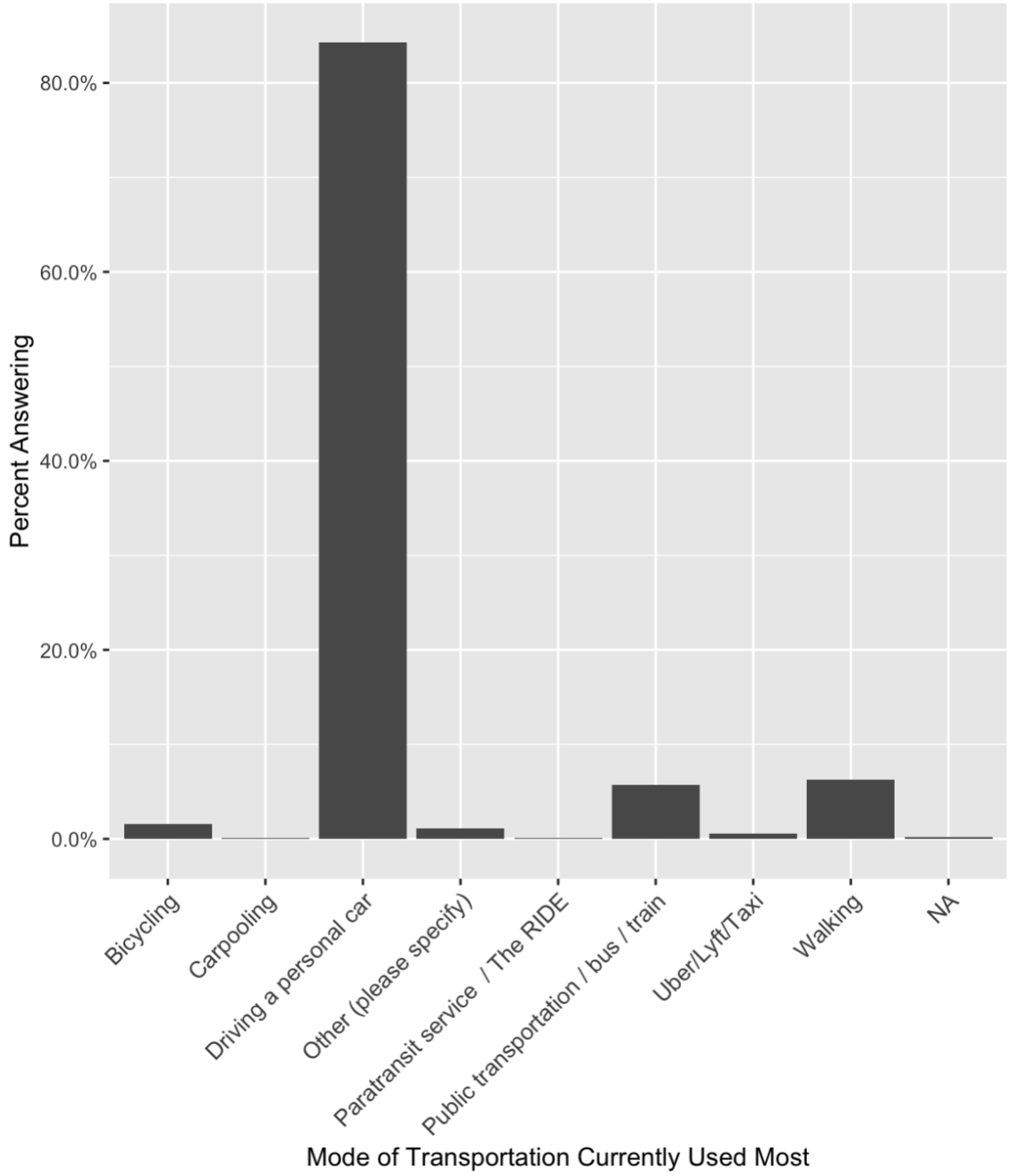
Results

From our research, we can confirm that many residents of Arlington currently use, and more still are open to alternative methods of transportation in addition to, or in lieu of personal motor vehicle use.

We created Figure 1 with the data from the 2019 Arlington Town Survey to look at which mode of transportation the 4,574 respondents currently use most. An overwhelming majority of respondents, over 80%, answered that driving a car is their most used form of transportation. As one can observe, in Figure 1, the vast majority of Arlington resident survey respondents get around using a personal car and the current public transit usage, at under 10%, is very low.

Figure 1

Histogram of 2019 Arlington Town Survey Transportation Most Used

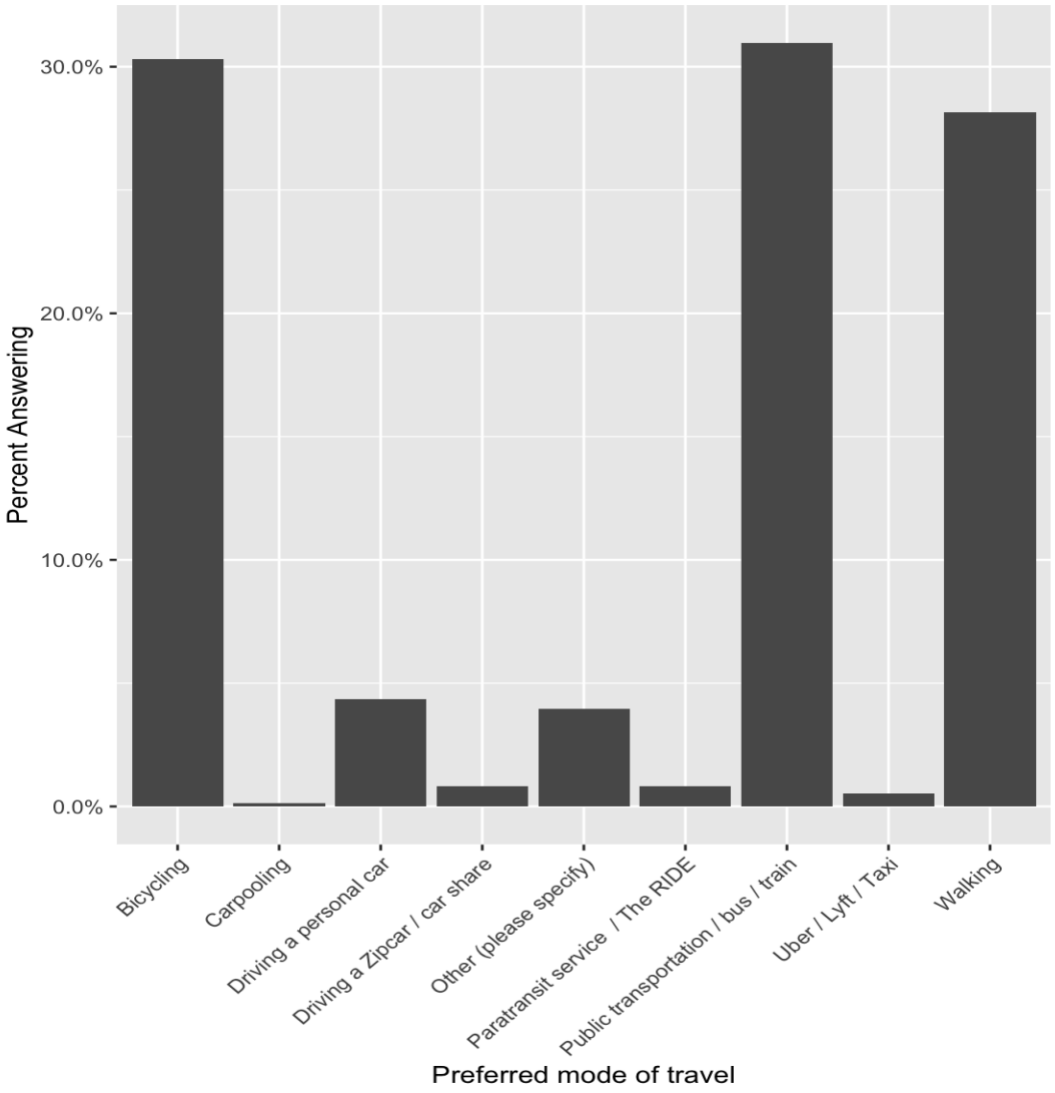


Out of the 4,574 respondents, 1,500 answered that they would be willing to, or want to, switch their main mode of transportation. From the 1,500 that stated they want to change their main method, and we created Figure 2 using this data to visualize the method of travel the respondents would prefer to use. We found that around 30% want their main mode of

transportation to be public transportation. 30% is a significant amount, and the potential of converting even 10% of these residents to busses could be enough to make a difference in the traffic and congestion in Arlington. We believe that implementing a bus shelter initiative in Arlington may induce residents who already are already open to changing their primary transportation mode, to choose public transportation.

Figure 2

Histogram of 2019 Arlington Town Survey Transportation Preferences



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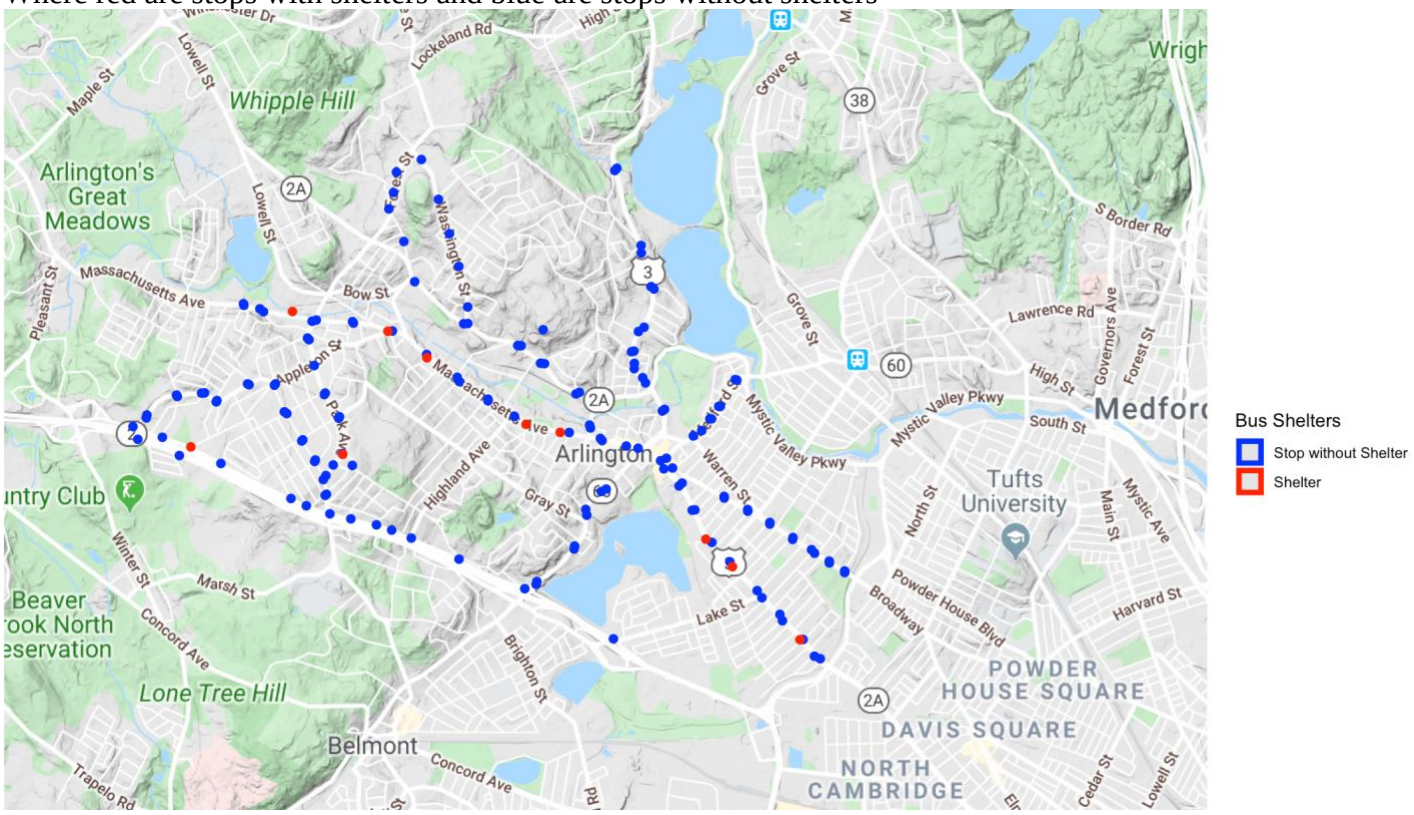
While one way of addressing a need for protecting bus riders is by providing more bus shelters, it is important to assess which stops are serving the largest number of transit riders based on an analysis of ridership data and average bus stop use. To do this we mapped the Town of Arlington and all of the 160 bus stops. The blue circles represent the 150 bus stops that do not have a bus shelter. Red circles represent the ten stops with bus shelters in place. As seen in Figure 3, we confirm that most of the bus shelters in Arlington are on Massachusetts Avenue.

Figure 3

Bus Stops and Bus Stop Shelters in Arlington, MA

Where red are stops with shelters and blue are stops without shelters

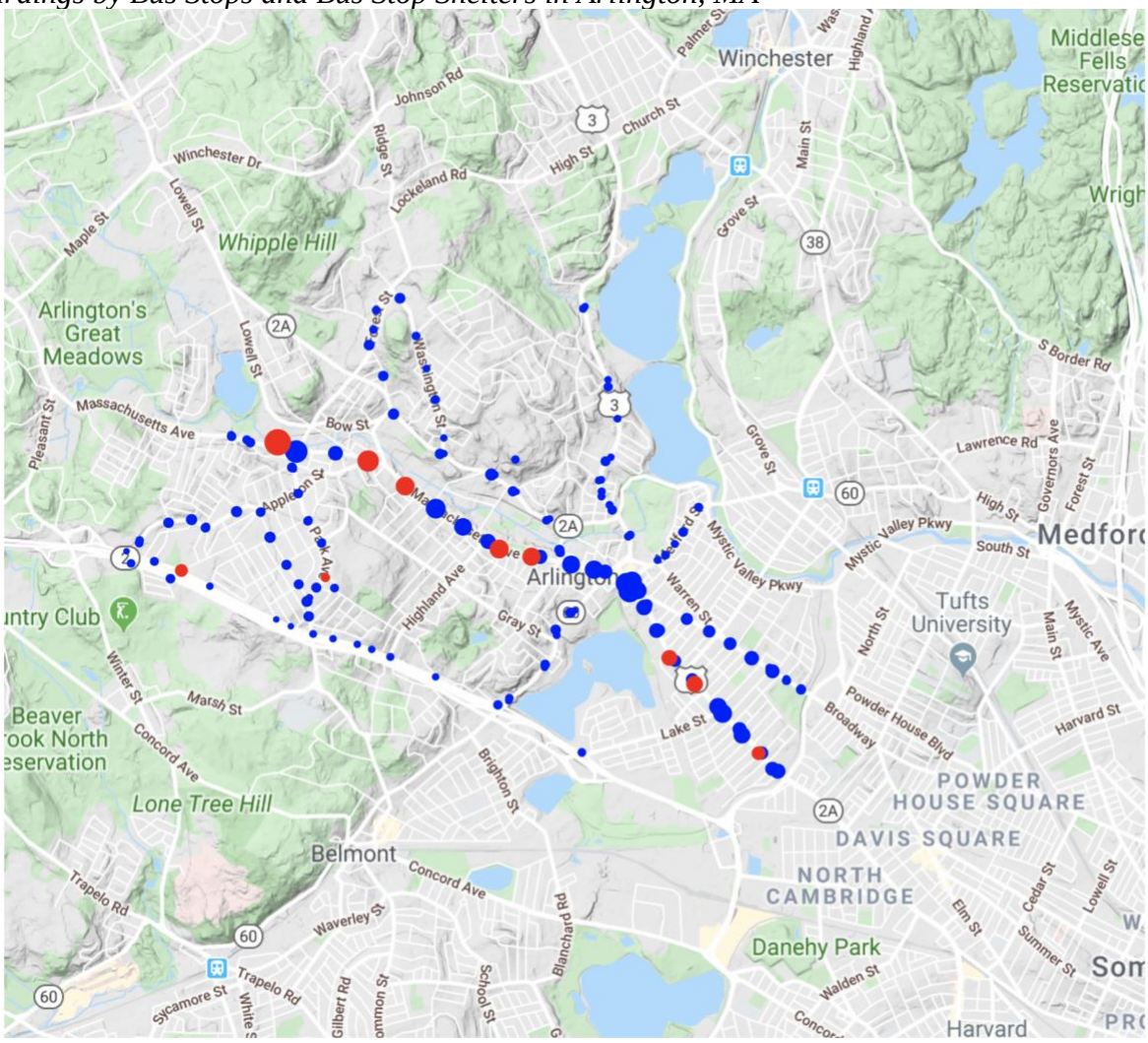


In Figure 4, we have taken the same map as before, but the size of the red circles and blue circles shown are relative to the average number of boardings at each stop. The dedicated

morning rush hour bus lane operates on Massachusetts Avenue and serves the 77, 79, and 350 bus lines, which all have high total boardings.

Figure 4

Boardings by Bus Stops and Bus Stop Shelters in Arlington, MA



We tested to see if the difference in boardings at stops with and without shelters was statistically significant. Our t-test output in Table 2 shows the means of boardings at bus stops with shelters and those without. The p-value shows that the results of this test are not statistically significant. However, this outcome is not evidence of a flawed assumption; rather this result is most likely due to the comparatively tiny sample size of bus stops with shelters.

Table 2

T-test of Bus Stop Boardings Without Shelters and With Shelters

Welch Two Sample t-test
Bus Stop Boardings with no Shelters and Bus Stop Boardings with Shelters
t = -0.71568, df = 10.27, p-value = 0.4901
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-17.848987 9.146946
sample estimates:
mean of x mean of y
25.44898 29.80000

We also wanted to keep groups who are more likely to be reliant on mass transit and/or have less political clout in mind in our research. Table 3 highlights several areas of importance and shows another opportunity to make changes that benefit the residents of Arlington. This additional layer of analysis should be completed before final locations are selected. Additional equity analysis could be looking at whether access to existing bus shelters is proportional to riders from under-resourced census blocks and then making decisions for new amenities with this in mind. It is important that new bus shelters and sidewalk upgrades be placed and maintained in an equitable, if not equal, manner. By analyzing ridership data, average bus stop use, census and environmental justice data, and stops that have sufficient space to create an ADA compliant bus stop, Arlington can focus on providing the most benefit to the most people with a likely additional benefit of having a noticeable reduction of personal vehicle traffic.

Table 3

Groups Likely to Rely on Transit or Least Represented in Political Power

2015-17 MBTA SYSTEMWIDE PASSENGER SURVEY					Reduced fare: incl. students/youth, disability passes and senior passes		Seniors
Bus Route	% walk/ bike to bus stop	% riders have alternate mode of transit (including alternate bus route/s)	% Household incomes are less than $43,500	% Minority (non-White riders)	% pay using reduced fare pass	% pay reduced fare pay-per-ride	% age 65 and above
62	86	63	26	25	16	17	15
67	99	59	10	22	11	11	11
76	89	65	10	40	8	13	10
77	98	65	35	24	17	18	13
78	98	65	20	34	16	19	18
79	97	65	19	22	11	22	18
80	97	75	24	28	8	10	7
84	98	59	8	17	7	0	5
87	99	74	25	22	9	9	7
350	87	56	36	38	9	11	9

2015-17 MBTA Systemwide Passenger Survey

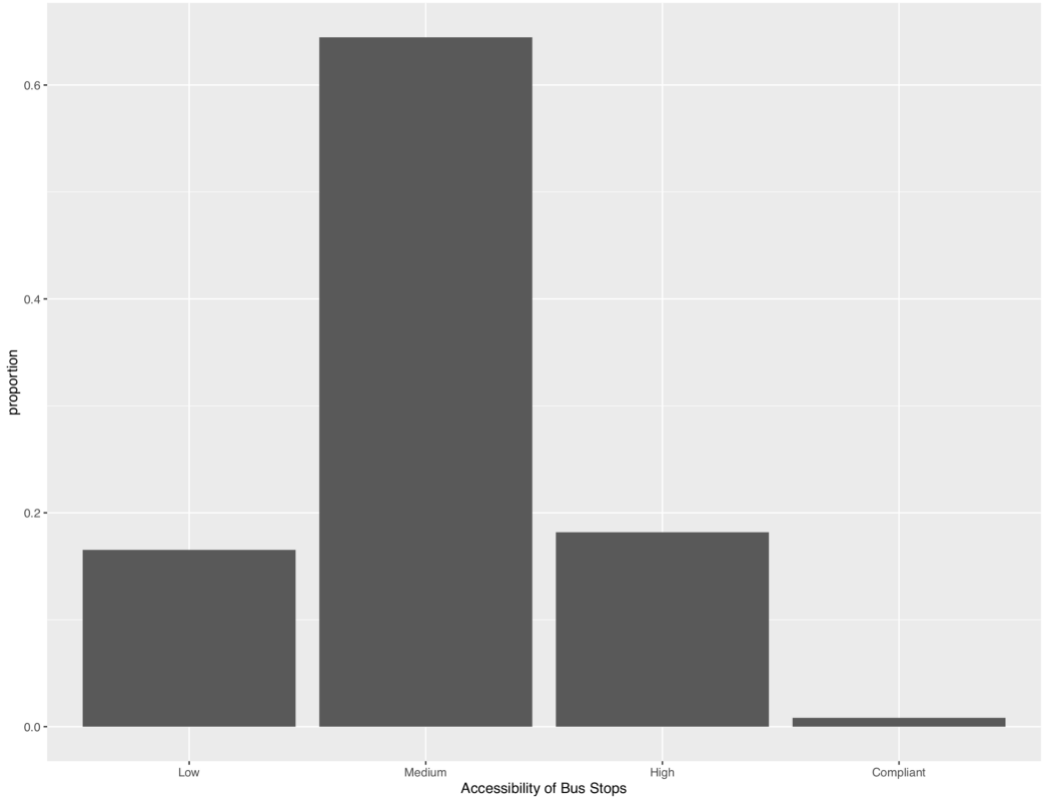
Arlington's ten bus lines as displayed above, are different from each other in a few particularly interesting ways. The 84 bus route stands out because it runs Mondays through Fridays and only during peak rush hours. The 84 bus route serves Alewife Station and the use of this route by commuting workers is emphasized by the fact that this route shows the smallest number of riders in the 65 and above age group, at just 5%. The benefits of this dataset are tracking data by route, applying applicable diversity metrics including age 65 and above, low income riders, percentage of minority riders by route and access to alternate transportation options. Limitations include the fact that we cannot track the exact proportion of reduced fare

riders and again, we do not know exactly where are riders reside. To further investigate the equity issues in Arlington, we looked at census data from 2010. According to the estimated census data, in 2017 85.2% of Arlington, MA residents were White or two or more races mixed with White and the Environmental Justice census blocks are clustered and easily identified.

In order to look at how Arlington can prioritize equity in terms of accessibility we analyzed the accessibility rankings of Arlington's bus stops from the MBTA bus boardings. We made Figures 5 and 6 to provide visual proportions of of ADA accessibility. The histogram in Figure 5 shows 2018 data for accessibility ratings based on analysis by the MBTA. The stops are ranked as having low, medium, or high compliance, or being fully compliant with ADA standards.

Figure 5

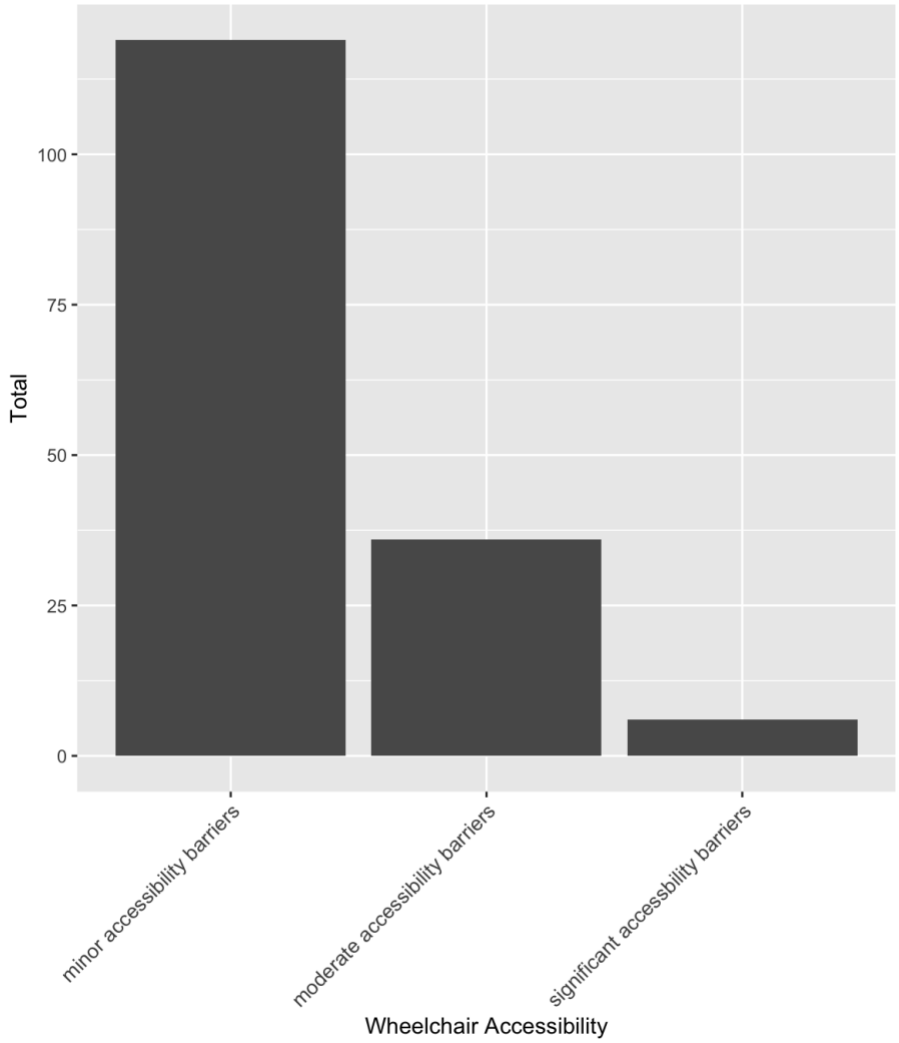
Histogram of Arlington Bus Stop Accessibility Ratings



Similarly, Figure 6 displays the wheelchair accessibility of the bus stops in Arlington. As can be seen, there is room for improvement regarding accessible bus stops in Arlington. A majority of the stops have medium to high accessibility access, as shown in Figure 5. All but one stop fall short of meeting ADA standards, which are updated regularly.. Similarly, as seen in Figure 6, the majority of stops have minor wheelchair barriers, but a little less than half of the stops have medium to high barriers. Due to barriers preventing full accessibility, individuals at most bus stops currently encounter at least minor physical barriers to using public transportation.

Figure 6

Histogram of Arlington Bus Stop Wheelchair Accessibility



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Proposed Reforms

With the MBTA contract for bus shelters ending soon, Arlington is at the precipice of a great opportunity to make capital improvements in their Town. The recommendations we are reporting, if implemented, could improve accessibility, quality of life, bus ridership, provide ad space for (local) businesses, and the leadership could negotiate a self-supporting revenue stream to cover the maintenance costs of shelters throughout the Town. We recommend that Arlington take on this initiative project to negotiate the installation of additional accessible bus shelters throughout the town of Arlington, concentrating on areas with high ridership and potential for increased public transport use.

Our policy recommendations were designed to make informed, strategic, and fiscally responsible changes to the face and function of Arlington's sidewalks and bus stops in ways that are mutually beneficial to the Town and to the MBTA. Research on bus stop amenities, including bringing bus stops up to ADA compliance and installing and maintaining shelters that provide seating and protection from the elements, have shown that better bus amenities increases ridership at walkable stops (Kim et al., 2018). Our policy recommendations are in line with bringing more sidewalks and bus stops up to code with the Americans with Disabilities Act, while beautifying neighborhoods by providing comfortable and well-maintained amenities. Arguably, by doing so, Arlington may hope to create benefits for its bus riders, pedestrians, and drivers by drawing more to choose the bus and improving their overall satisfaction.

In terms of creating more safe, protected areas to wait for buses in Arlington, it is also important that capital investments and improvements be provided in such a way as to benefit diverse residents of Arlington. We recommend that the Town of Arlington perform an Environmental Justice equity analysis so that they can be confident that new shelters and related

capital improvements are distributed equitably across all Arlington neighborhoods in need. This further layer of research would cross-reference using the most recent MBTA ridership data.

We hope that an additional outcome of completing accessibility and amenity improvements will be to move Arlington travelers from using their car to choosing the bus and higher satisfaction ratings on future Town surveys. And that, if more Arlington residents choose to take the bus instead of driving their cars, Arlington may see a decrease in traffic and congestion. We are aware that measuring traffic and congestion will require specific attention and reference data to determine effective change. If congestion research is not completed, we can still hope to see some movement in current transportation use responses and preferences over the next several years of the Arlington surveys. Certainly, tracking these data year-over-year to identify specific changes and overall trends is an exciting area for further research.

It should be noted that limitations do exist within our analysis. For example, by studying line data, we cannot determine exactly where riders live or begin their trips, such that tracking riders across the system to determine what proportion of riders on Arlington line busses are resident in, or employed in Arlington, is not possible. This limitation is a minor impedance because our policy recommendations are designed to benefit bus riders waiting at stops in Arlington, and to incentivize local residents to choose to utilize the busses because comfortable and accessible bus stop amenities are provided. Feedback from the Arlington leadership team included information that additional accessibility improvements have been completed in the past year that are not reflected in the 2018 MBTA data. As the nature of the contracts are not yet decided, there are a number of options for the Town to consider regarding funding the maintenance costs of the bus shelters which include sidewalk upkeep and snow removal. One option for the Town is to allow a contracted company to sell advertising on the shelters.

Additionally, advertising by local Arlington business owners could be ideal for maintaining and increasing the community feeling by encouraging residents to dine, shop, and have more of their social and shared experiences in Town. The Town Surveys collect shopping data and it is possible to track changes year over year.

Arlington may choose to invest in improving the highest ridership stops first or focus on the stops requiring the least amount of time and money to bring up to ADA compliance. One stop is listed as fully compliant and roughly 65% are at medium rating, while the remaining 35% are divided between low compliance and high ratings. Some of the decisions for which bus stops to prioritize cannot be made purely by using data analysis. For example, there may be greater benefit to more people by improving the accessibility of the few low-rated stops or by improving stops with minor accessibility barriers. Further research could investigate the nature of the barriers and determine whether alternative solutions exist, such as moving a bus stop a short distance such that the area where a kneeling bus could board passengers is part of the protected, no parking zone of the bus stop.

The results from the various data used allowed us to include considerations for equitable distribution of amenities. Our hope is that Arlington will use our data and further research to thoughtfully consider the needs of riders who may have fewer alternative options, reside in areas that are currently under resourced, and are likely to be members of underrepresented groups and make data-driven decisions. We hope that our research can help improve the quality of life and accessibility for Arlington residents across all income brackets and groups.

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