

Factors associated with the rate of bike plan implementation in

American cities

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Abstract

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Most major American cities have been building out the infrastructure envisioned in their bicycle master plans for at least a decade. Many municipal departments of transportation are steadily building what their plans say they should, some are rapidly expanding their infrastructure, but some are lagging. Although researchers are studying the effects of this infrastructure and professional organizations are tracking its expansion, few so far have examined the different political, economic, and other factors that might be responsible for the differences in the rate at which cities are able to build their bike plans. This thesis develops a methodology for calculating the compound annual growth rate of bike lane networks in American cities based on longitudinal survey data collected by the Alliance for Walking and Biking and League of American Bicyclists since 2007, and then compares each city's growth rate against factors such as political turnover, annual precipitation, and funding that could be associated with different levels of success. While many patterns are evident, very few are statistically significant. Based on this research, bike lane implementation appears to be a highly individualized process driven by factors that are difficult to measure or understand at a national scale.

Table of Contents

1	Introduction	6
1.1	Background	6
1.2	Research objectives	7
1.3	Hypothesis.....	8
2	Literature Review.....	9
2.1	Theory	9
2.1.1	Theories of plan implementation	9
2.1.2	Barriers to implementation of a single transportation project	10
2.1.3	Determinants of transportation ballot measure success	11
2.1.4	Studies of citywide transportation plan effects.....	12
2.2	Advocacy Organization Reports.....	13
2.2.1	NACTO - Green Light for Great Streets	14
2.2.2	PeopleForBikes - Green Lane Project Protected Bike Lane Inventory.....	15
2.2.3	PeopleForBikes - City Rankings Tracking.....	16
2.2.4	League of American Bicyclists - Alliance for Biking and Walking survey	18
2.3	Public and Private Plans and Reports	19
2.3.1	Evaluations of citywide transportation plans in individual cities	20
2.3.2	Datasets measuring attributes of cities	20
2.4	Literature review summary.....	22
3	Methodology.....	24
3.1	Tracking Implementation.....	24
3.1.1	Establishing definitions	24
3.1.2	Alliance for Biking and Walking survey data.....	27
3.1.3	Selecting a metric for bike lane growth.....	28
3.1.4	Supplemental sources and quality issues	31
3.2	Variable Selection	32
3.2.1	Political factors.....	33
3.2.2	Economic factors.....	34
3.2.3	Implementation Factors.....	35
3.2.4	Transportation factors	36
3.2.5	Bicycle factors	37

3.2.6	Weather and climate factors	39
3.2.7	City-specific factors	39
3.2.8	Data management and collection	40
3.3	Statistical Analysis.....	41
3.3.1	Statistical Tests for Categorical Factors	41
3.3.2	Correlation Testing and Univariate Regression for Continuous Factors.....	42
4	Results.....	44
4.1	Compound Annual Growth Rate Results	44
4.2	Statistical Tests on Categorical Factors.....	47
4.2.1	Political factors.....	47
4.2.2	Economic factor	49
4.2.3	Bicycle factors	49
4.2.4	City-specific factors	50
4.3	Statistical Tests on Continuous Factors	51
4.3.1	Significant and potentially significant factors	53
4.3.2	Economic continuous factor	56
4.3.3	Implementation	57
4.3.4	Continuous bicycle factors	58
4.3.5	Continuous climate factors	61
4.3.6	City-specific factors	62
5	Discussion.....	65
5.1	Non-significance.....	65
6	Conclusions	68
6.1	Summary of results	68
6.1.1	Political factors results.....	68
6.1.2	Economic factor results.....	69
6.1.3	Implementation factor results	71
6.1.4	Transportation factor results	72
6.1.5	Bicycle factor results	72
6.1.6	Weather and climate factor results	74
6.1.7	City-Specific factors results	75
6.2	Limitations.....	76
6.2.1	Timespan.....	76
6.2.2	Omitted Variables	77
6.3	Avenues for further quantitative research	78

6.3.1	Alternative Metrics and Evaluating Other Infrastructure Types.....	78
6.4	Avenues for further qualitative research.....	80
6.5	Additional infrastructure worthy of further study.....	81
7	Works Cited.....	83
8	Appendix A: List of cities.....	85
8.1	Cities.....	85
8.2	Smaller cities.....	85
9	Appendix B: 2018 Benchmarking Survey Instrument.....	86

1 Introduction

1.1 Background

Most American cities now have a variety of citywide transportation plans to improve conditions for people walking, biking, and taking transit. Now that most cities are at least a decade into implementing these, it is an appropriate time to review which are building the fastest, which are falling behind, and the reasons for any differences. This thesis studies which factors are most associated with faster or slower rates of bike lane implementation in American cities in order to help planners adapt to changing conditions within their city.

Some cities have followed their plans and are building out their networks at a reasonable pace. Other cities have delayed and canceled many portions of their plan. And a few cities are sustaining a rapid pace and installing mile after mile each year. Many different factors could be affecting this, including overarching international and national trends as well as factors unique to each city. Researchers and practitioners have only just begun to study these factors, and so it is unclear what may be affecting the rate of bike plan implementation on a national scale.

For example, cities with a temperate west coast climate, where it is rarely too cold for concrete to cure and rarely so hot that labor must stop, will have more time available during the year to work on construction projects compared to a Midwestern city with a harsh seasonal climate. Thus we may expect that it is easier for the west coast city to complete transportation projects than a Midwestern city with a climate characterized by a harsh seasonality that leaves less time available for construction. A city that has a healthy budget will likely be able to consistently make faster progress on its transportation plan compared to a city that lurches from budget crisis to budget crisis. And a city that already has relatively popular bike commutes might progress faster thanks to greater enthusiasm than a city where biking is a

rarity. But without an existing body of research, it is difficult to know what does and does not matter when it comes to building out bike plans.

1.2 Research objectives

This thesis is an exploratory data analysis that attempts to identify the factors that most affect the build-out of successful and unsuccessful bicycle plans. It describes prior and current research in this area, the methods used therein, the results, and their implications. The focus of the project is on the construction of on-street bike lanes, one subset of American cities' current push for cleaner and safer transportation infrastructure. Other forms of bicycle infrastructure, bus improvements, and fixed-guideway transit such as light rail are also worthy of study. However, these types of projects have much longer time frames and are often complex multi-jurisdictional projects with a decade or more of planning, design, and construction required before the public can use them. Limiting this thesis to on-street bike lanes removes most of the jurisdictional issues that complicate other transportation topics and focuses on a type of infrastructure that is now universal in American cities.

Transportation plan implementation, as in all political decision-making, is the result of a complex process of competing values, personalities, and resources. While the factors studied in this thesis combined may ultimately not be able to explain all of the variation of bike lane construction rates in cities, they can at least alert practitioners as to what accelerates, slows, or has little effect on bike lane implementation rates. This knowledge can be utilized by public agencies and their consultants as they develop or implement their citywide transportation plans. Many of the factors studied in this thesis, such as the presence of a dedicated implementation committee or the number of staff working on bicycle and pedestrian projects, can be directly addressed by planners during the drafting of a new transportation plan. If the research finds that the presence of an implementation committee has little effect on the actual implementation of the plan, then perhaps the committee's focus or goals could

shift. Other factors could be addressed during the implementation of individual projects, but most of the forty-three factors included in this study are beyond the direct control of the planners and engineers implementing citywide transportation plans. Some are included as control variables, but identifying which ones have the most impact on their work can help them adapt existing plans to changing conditions and focus on how to make them more resilient to external change when it is time to update or draft a new plan. For example, if this work found that rapid political turnover was a strongly detrimental to plan success, then the agencies responsible for implementing bike plans may wish to do greater outreach to newly elected officials or work with them to rebrand and revise the previous plan to help new officials feel ownership over the plan.

1.3 Hypothesis

The core hypothesis of this thesis is that there are measurable and meaningful differences in the rates at which cities are building bike lanes, and that factors can be identified that may be responsible for the different rates accomplished by cities. This examines how different political, economic, plan implementation, transportation, climate, urban form, and demographic trends or traits in cities are associated with the rates at which they are building out their bike lane networks.

2 Literature Review

This section describes prior research into transportation plan implementation with a focus on projects most relevant to this thesis. It concludes with a discussion of current trends and gaps in the literature that this thesis aims to fill.

2.1 Theory

2.1.1 Theories of plan implementation

Many authors have studied the general implementation of plans and policies. In their book *Implementation*, Pressman and Wildavsky (1973) provide a highly regarded dissection of failures in implementation during the War on Poverty era in Oakland, as well as greater lessons to be learned based on that case study (Wegrich 2016). They provide a useful and encompassing definition of implementation as “to carry out, accomplish, fulfil, produce, complete” plans and policies that have already been adopted or enacted. In their case study they note the issues with the initial design of the Oakland Project where a rural economic development strategy was poorly adapted to an urban context. This finding is then extended to implementation in general with a model that predicts that as the number of clearance points and organizations involved in implementation of a policy increases, so does its likelihood of failure, or at the very least its financial cost and time until it produces results (Wegrich 2016). This is especially true when the actors involved in implementation have different goals, a process that Bardach (1977) explored in his book *The Implementation Game*. This book took a closer inspection of the political “games” that are played by different agencies and individuals involved in the implementation of a policy (Wegrich 2016). Each of these actors is engaged in negotiations, bargaining, and exchanges with its partners in policymaking and implementation. Successful policies must be crafted such that they can pass through this process and come out on the other side intact, while also being quick enough to still be relevant to the problem that they are trying to solve.

One approach to plan implementation evaluation is conformance-based, where success would be defined as building each individual project when, where, and to the level of quality specified in a city's bike plan. Evaluating plans using a conformance-based approach can be appropriate for single-city and short-range applications, but becomes unwieldy and to some extent unrealistic when comparing long-range plans across many cities (Laurian 2004). Conformance-based plan evaluation tends to penalize planners who adapt to changing conditions by changing their plans. An example is if specialized federal grant funds became available for a lower-priority transit project, causing that project to be built before a higher-priority project. While this would lead to a lower conformance value by ignoring the transit plan's prioritization scheme, the true value to a city may be higher as the city was able to seize an opportunity and get a project built at lower direct cost.

2.1.2 Barriers to implementation of a single transportation project

Several authors have used qualitative methods of policy analysis to examine barriers to effective implementation of a particular kind of transportation project. One example from Europe examined a handful of light rail and streetcar projects in the Netherlands and France to determine what led to different outcomes among several proposed projects (Van Oort, van der Bijl, and Roeske 2015). Two other examples include studies of bus rapid transit projects, which have similar transportation goals but attempt to be quicker and less expensive to implement than light rail projects (Mallqui and Pojani 2017; Ardila 2002). Both Van Oort et al. (2015) and Ardila (2002) framed their work as a comparison of success and failure, defining success as when a proposed project was actually funded and built and failure as when a proposed project has lingered in the planning phase or been outright canceled or replaced with a lower-quality alternative. The three papers identified changes in project scope, conflicts with other projects, political turnover, poor outreach and a slow schedule as making it harder for a project to succeed. Conversely, a planning process that is tightly linked with later engineering and construction

phases, has good communication with the public and with elected decisionmakers, and outlines its own implementation methods can lead to a more successful plan. While all of these authors examined transportation projects outside of the United States, the topics they cover are generalized enough that they are still relevant to this thesis. For example, Van Oort et al.'s (2015) discussion of political turnover focuses on broad processes such as how elected politicians who approved plans eventually leave office, and this change often results in those plans being less likely to succeed, rather than discussing how the specific structure of Dutch municipal councils could lead to better or worse project outcomes. This gives that work useful external validity and suggests that political turnover should be studied as a factor in this thesis.

2.1.3 Determinants of transportation ballot measure success

Another group of researchers examined what traits within a jurisdiction make it more or less likely for a transportation ballot measure to be successful in a public election in the United States. These studies use quantitative methods, but the two examples included here found weak statistical relationships. The first study provided a tightly focused look at two competing ballot measures in San Francisco and attempted to determine whether voters who use different modes of transportation were more likely to vote for the proposal that most benefitted their mode (Palm and Handy 2018). It found that people who identified primarily as cyclists voted strongly for their mode, but transit users and drivers did not. Instead, the latter groups voted with their overall beliefs on sustainability, their view on what was best for the city, their views on taxation, and their personal financial situation. Another study used quantitative methods to compare the outcomes of several dozen ballot measures from the American west coast to see if various demographic factors within different communities could explain success or failure of transit districts and bond measures at the ballot box (Herrman and Lewis 2018). This study found that only the proportion of residents within a city who were elderly was a statistically significant

predictor — a higher share in elderly voters makes it more difficult to pass a transportation ballot measure. All other variables — such as racial and gender diversity, city size, population density, education attainment of residents — were not significantly linked to ballot measure passage. This suggests that other variables could have been more important as predictors, or that individualized processes within the cities such as political campaigning and get-out-the-vote organizing determines ballot measure outcomes. Their study is similar in structure to this thesis, and so serves as a cautionary tale on the difficulty of selecting the right variables and making sure to use a dataset with enough cities to produce statistically valid results.

2.1.4 Studies of citywide transportation plan effects

Some researchers are collecting quantitative information on citywide transportation plans and using them to compare the effects of the plans in different American cities. One foundational work in this area summarizes the prevalence of bicycle and pedestrian master plans and traits in the communities that have published them (Steinman et al. 2010). For example, communities that have adopted these plans tend to be slightly less racially diverse and have a slightly higher walking commute share, but are generally not different from the nation as a whole on other variables like age and income. Peterson et al. (2018) surveyed city officials across the United States in a similar study of municipalities that have adopted various types of transportation or land use plans and found that 48% had a bicycle and/or a pedestrian plan, which was slightly lower than the 64% of communities that had a comprehensive plan. They also found that transportation network plans tend to be more common in larger cities than smaller towns, and so excluding smaller communities from this thesis may be acceptable. Kerr et al. (2013) performed a novel study that gathered information on bicycle and pedestrian plans published by North Carolina municipalities and compared traits in those communities against those with no plan. They found that the presence of a pedestrian master plan or similar document was associated with lower

injury crash rates for people walking, but that presence of a bicycle plan had no significant effect on injury crash rates for people riding bicycles. Studies like these provide excellent background information that provide context for how common these plans are and whether they seem to have effects on outcomes like injury rates.

2.2 Advocacy Organization Reports

Three organizations are currently active as both researchers into bike plan implementation and as advocates for it. First is the National Association of City Transportation Officials (NACTO), a professional organization focused on sustainable urban transportation. They focus on drafting and disseminating training and design manuals, lobbying state and national governments, and supporting research. NACTO's work was historically a "purposeful contrast" to the American Association of State Highway and Transportation Officials (AASHTO), whose design manuals and training courses were perceived to be inappropriate for urban contexts (Lydon 2012). Membership in NACTO is open to municipal departments of transportation and similar government agencies such as public works departments and transit agencies; as of May, 2019, there are 68 North American cities and 11 transit agencies involved in the group (NACTO 2019). These members pay the membership dues that fund NACTO, which also receives some revenue from its events and the sales of design manuals. NACTO is staffed mostly by transportation planners, engineers, and other professions that mirror roles within transportation agencies. The organization is overseen by a board of high-ranking officials from municipal transportation agencies.

Second is PeopleForBikes, a hybrid advocacy and trade group that offers grant programs and research initiatives focused on encouraging cycling in the United States. The advocacy and trade group arms of the organization are legally distinct but closely linked, and are staffed by and overseen by a mix of transportation researchers and bicycle company executives. Its current focuses include promoting the

construction of bicycle infrastructure, lobbying for laws and trade policy to support the bicycling industry, and increasing ridership in general. Funding comes from bicycling industry companies such as major bike retailers and manufacturers as well as donations and memberships.

Third is the League of American Bicyclists, an advocacy group currently focused on federal lobbying for supportive bicycle laws and more bicycle funding, evaluating cycling conditions across the country, and supporting bicycle education. It has its roots in the 19th century League of American Wheelmen, which was once responsible for organizing nearly all aspects of competitive and recreational cycling (Finison 2014). Today it is primarily funded by event fees and individual memberships. Staff include a mix of transportation researchers and advocates, and the group is overseen by cycling instructors, bicycle company executives, and transportation advocates.

The three groups together provide a robust set of research and initiatives, sometimes complimentary and sometimes competitive with each other, that provide most of the data used in this thesis. The following section discusses some of the research products provided by these organizations.

2.2.1 NACTO - Green Light for Great Streets

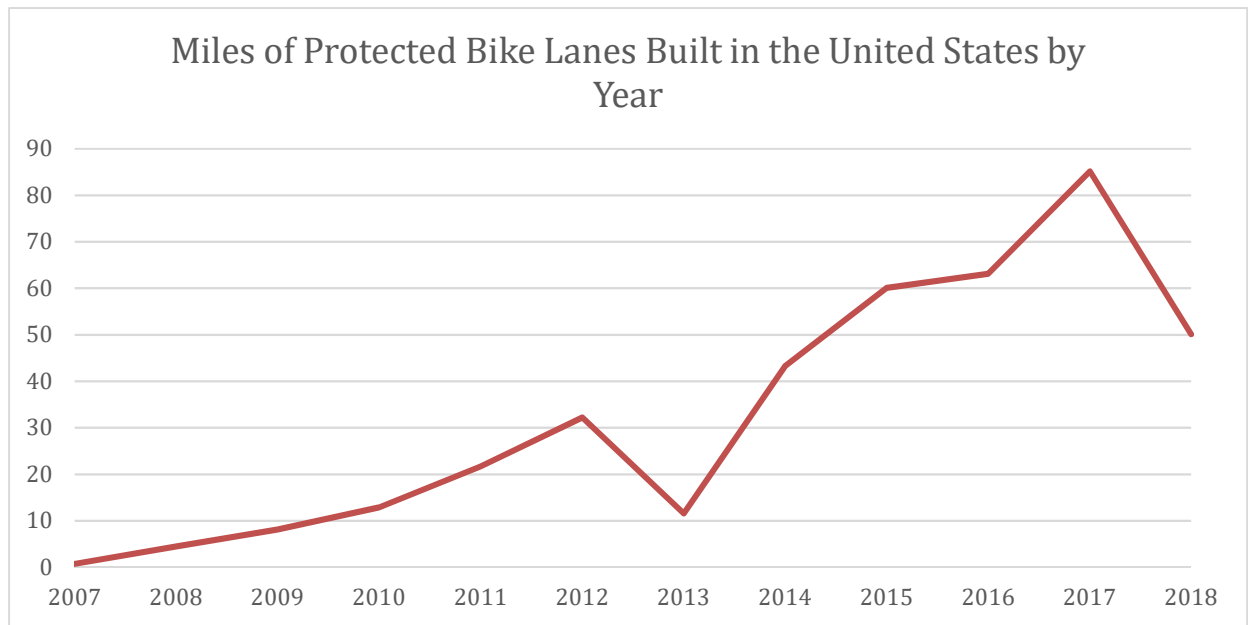
NACTO recently surveyed cities across the United States to determine what was delaying efforts to implement transportation plans (NACTO 2018). As the professional organization responsible for publishing many of the standards adopted by city transportation departments building safe and multimodal streets, they wished to see how their recommendations were actually being used by practitioners. In the Green Light for Great Streets project, they found that municipal transportation agencies that are successfully implementing their plans tended to have an accepted and clear plan, rigidly defined workflow within transportation agencies, standardized designs, avoided the use of external consultants for routine work, and had a well-defined plan evaluation system. These agencies

are supported by stable political buy-in and the use of recurring funding sources rather than grants or one-off projects. NACTO put some of these recommendations into action by working with the cities of San Jose and Pittsburgh in 2017 and 2018 before releasing their first report in September, 2018. No additional products from the Green Light for Great Streets project were available at the time this thesis was published, but ongoing quantitative and qualitative work by NACTO is likely to yield useful insights for transportation planners across the country. NACTO has not yet collected a longitudinal dataset tracking progress building transportation infrastructure beyond a year or two. With time it could become a critical source of data for some of the implementation variables affecting plan build-out that are generally opaque to the public, such as the use of consultants and staff turnover. However, the lack of data from the late 2000s and early 2010s makes it impossible to use NACTO's early findings as part of this project.

2.2.2 PeopleForBikes - Green Lane Project Protected Bike Lane Inventory

One of PeopleForBikes' projects most relevant to this thesis was the Green Lane Project, an initiative designed to help cities install protected bike lanes between 2011 and 2016 (PeopleForBikes 2016). In addition to providing grants and technical assistance to cities interested in installing protected bike lanes, PeopleForBikes staff also began to track the implementation of these projects across the country. The result was a public dataset available as an online Google spreadsheet that includes every known protected bike lane in the country. This dataset has been continuously updated by PeopleForBikes staff even though the Green Lane Project has ended (PeopleForBikes 2019). As of March, 2019 this source has 578 projects included along with centerline mileage, the date of construction, name, location, as well as several attributes describing its construction (PeopleForBikes 2019). Figure 1 below shows the total mileage of protected bike lanes built in the United States in each year from 2007 to 2018, the time period also covered by the Alliance for Walking and Biking survey data used in this thesis.

Figure 1: Protected Bike Lane by Year from PeopleForBikes Green Lane Project



It represents each protected bike lane project as an individual record, with columns storing project attributes, such as materials used to provide separation between the bike lane and general traffic lane, the duration of the project, and the year of completion. Attributes also include notes and links for most of the projects that enable researchers to explore further. The dataset can be used to track the implementation of protected bike lanes over time, and PeopleForBikes found through their national inventory that this type of infrastructure has generally doubled each year (PeopleForBikes 2016). Unfortunately for the purpose of this thesis, the narrow focus on only a single kind of bike lane makes it unsuitable for tracking bike lane construction rates in general across the country. The relatively low national mileage of protected bike lanes is also far smaller than the mileage for all bike lanes, and they are present in fewer cities.

2.2.3 PeopleForBikes - City Rankings Tracking

Following the Green Lane Project, PeopleForBikes began a follow-on project called PlacesForBikes. The project has two main components – the Big Jump project to help cities accelerate the build-out of their

cycling networks, and the City Rankings project to quantify how each American city scores on a number of factors relating to urban transportation cycling (PeopleForBikes 2019). The 2018 data release of the City Rankings was the inaugural product from this initiative and rates 484 cities according to their levels of bike ridership, safety, the existing bike network, the recent growth of the bike network, and the ability of the bike network to reach all city residents. Data are presented in an online dashboard, a customized report for each city, and a dataset available for public use.

Much of the City Rankings project is rooted in the Bike Network Analysis (BNA), a GIS approach that evaluates the level of traffic stress that cyclists must experience in order to reach key destinations (PeopleForBikes 2018). The BNA uses publicly available GIS data from the collaborative OpenStreetMap project, a user-created and maintained alternative to mapping platforms such as Google Maps that operates similar to Wikipedia's volunteer-driven content structure. When OpenStreetMap data for a particular city is of low quality, city staff can send in their own GIS files to PeopleForBikes for analysis as an alternative source. Cities with schools, shopping centers, parks, and other destinations along high-quality bike lanes are scored highly under this system. The results of the BNA are used to create a Network score, and changes in the Network score from year to year are used to develop an Acceleration score that enables the relative rate of bike network expansion to be measured in cities and towns across the United States. Both the Network score and the Acceleration score use the BNA for 80% of the total score, and the remaining 20% is supplemented by a survey that is sent out to bicycle advocates, industry members, and the general public across the United States. The survey asks about amenities such as mountain bike parks, paved versus unpaved trails, events, and other topics that are difficult to quantify from a national perspective or with a GIS approach. It also asks for a subjective assessment of how well each city is implementing its bike plan.

The mixed GIS and survey approach yields a highly usable and comparable dataset for measuring the extent and growth of bike networks. The 2018 data release was followed by an update released in May, 2019. Although the 2019 update makes City Rankings available online through a data dashboard, no full dataset was publicly available at the time of this thesis' publication. With only two years of data it is difficult to measure each city's sustained ability to implement their plans, a task that will become possible given more years of data.

2.2.4 League of American Bicyclists - Alliance for Biking and Walking survey

The Alliance for Biking and Walking performed a study every two years in which they sent survey packets to state and city transportation staff in order to gauge to what extent state and local governments are supporting active transportation (The Alliance for Biking and Walking, 2016). The Alliance was a coalition of diverse advocacy groups such as the American Association of Retired Persons (AARP), the League of American Bicyclists as well as dozens of smaller groups that use the data to report on quantitative measures of success and implementation. Funding was provided from the member organizations that made up the Alliance for Biking and Walking as well as government agencies such as the federal Centers for Disease Control, the Nelson\Nygaard consulting firm, and local governments such as the city of Fort Collins, Colorado. In 2016 the Alliance for Biking and Walking ceased operations and transferred its assets and projects to other organizations. As of 2018, the survey and benchmarking projects are now managed by the League of American Bicyclists with continued support from many former Alliance for Biking and Walking partners.

The full survey is extensive and includes several hundred questions, which the Alliance then complements by pulling in datasets from the US Census' American Community Survey, Bureau of Labor Statistics, National Center for Health Statistics, and more. The full version of their final dataset includes over 750 columns of data for 69 cities in 2016, the most recent version of the full dataset. A new report

was released in December, 2018 providing an up-to-date summary of a variety of walking and bicycling data trends collected from the most recent survey administered by the League of American Bicyclists for the first time. While a full dataset was not available at the time that this thesis was written, most of the survey results provided in the report were transcribed into a usable data format to provide the most up to date data possible. The 2016 dataset also includes data from prior surveys back to 2007, and older data dating back to the first survey in 2002 is available by request.

This 2016 survey dataset combined with transcribed columns from the updated *2018 Benchmarking Report on Bicycling and Walking* is the main dataset used in this report. The data contained in the survey results includes most of the data necessary to complete this project. It is unique for its national coverage and longitudinal nature, but has some issues that will be discussed in the Methodology section of this thesis. Each edition of the *Benchmarking Report on Bicycling and Walking* report and underlying data have been cited in numerous studies and reports. For example, the case study *Healthy by Design: Using a Gender Focus to Influence Complete Streets Policy* used the Alliance for Walking and Biking report to discuss the role of gender in Complete Streets policymaking (Keippel et al. 2017). The quantitative study *Why cities with high bicycling rates are safer for all road users* used the Alliance for Walking and Biking data as one of several data sources studying the links between bicycle infrastructure and bicycle usage rates and general road safety (Marshall and Ferenchak 2019).

2.3 Public and Private Plans and Reports

The research described above covers transportation plan implementation from a theoretical and a targeted research perspective. In addition, there is a literature of practice produced by governments and corporations that are either studying similar topics, using similar methods as this thesis, or are used as data sources for the factors used in this thesis.

2.3.1 Evaluations of citywide transportation plans in individual cities

It is common practice among public agencies to periodically evaluate plans and programs that are underway, and to launch pilot programs designed to test new programs, services, and regulations. Cities have been publishing citywide bicycle plans for decades, and planning literature that rigorously evaluates them dates back at least 40 years. The 1979 report titled *Evaluation of the Eugene Bikeways Master Plan* is a typical example, as it reflects on several years of progress made to improve cycling conditions in Eugene, Oregon following the adoption of that city's first bicycle master plan (Regional Consultants 1979). The consultants hired to produce the report evaluated progress building bikeways, reported on what was built, and suggested improvements based on their expert judgment as well as a survey of riders and crash data analysis. Similar studies continue to be produced either as part of research or commissioned by local governments. *An evaluation of the implementation of the Seattle Bicycle Master Plan* is an example of one of these one-off analyses (Rose 2011). This evaluation explores the 2009 edition of the Seattle Bicycle Master Plan after the first few years of implementation for pace and for its ability to equitably serve its city. While these evaluations are helpful to the planners and engineers implementing the current plan and preparing the next one in a given city, they are too varied in form, method, time, and space to be compiled into a meta-analysis that covers multiple cities. These studies could be useful for the current project by providing extensive detail on a single city, such as how plan oversight influences the relative success of building out plans in specific cities for which such studies exist (e.g., Seattle, Nashville).

2.3.2 Datasets measuring attributes of cities

In order to accomplish the goals of this thesis, data must be obtained that measure factors that might be associated with the rate of bike lane construction. Two key sources were citywide summaries produced by Redfin's Walk Score[®] division and by the Wallethub company.

2.3.2.1 Walk Score[®]

The online real estate company Redfin's Walk Score[®] division measures the walkability of neighborhoods in order to provide that information as part of real estate listings (Walk Score 2019). Although providing information to renters and home buyers is its main goal, Walk Score[®] has become a metric commonly used to measure walkability in research projects. Walk Score[®] is closed-source and the full methodology is not public, but the general methodology is outlined by Redfin:

“Walk Score measures the walkability of any address using a patented system. For each address, Walk Score analyzes hundreds of walking routes to nearby amenities. Points are awarded based on the distance to amenities in each category. Amenities within a 5 minute walk (.25 miles) are given maximum points. A decay function is used to give points to more distant amenities, with no points given after a 30 minute walk.

Walk Score[®] also measures pedestrian friendliness by analyzing population density and road metrics such as block length and intersection density. Data sources include Google, Education.com, Open Street Map, the U.S. Census, Localeze, and places added by the Walk Score user community.”

In addition to the company's eponymous Walk Score[®], they also produce a similar Bike Score[®] and Transit Score[®] that measure the bikeability and transit-friendliness of cities. The methodologies for these two scores are similar to the original Walk Score[®], however they place more of an emphasis on the actual infrastructure available to ride a bicycle or take transit than Walk Score[®], which is more focused on amenities such as walking distance to libraries or coffee shops.

The three different scores for each city used in this thesis were joined to the Alliance for Walking and Biking 2016 dataset by the Alliance for Walking and Biking. Although their closed-source nature makes it

difficult to fully understand their methodology, the three Walk Score[®] metrics are often used in research projects due to their simplicity and ease of use and national comparability.

2.3.2.2 Wallethub Indexing

Wallethub is a company with a focus on the consumer credit reporting industry, but it also has a research and statistics division that has produced several dozen different rankings and economic indices of American states, metro areas, and cities. This thesis makes use of one of these ranking projects, intended to rank American cities according to the overall quality of each city's leadership. The "Best- & Worst-Run Cities" is an index-of-indices that uses sub-indices to measure financial stability of local government, educational attainment and quality of schools, health infrastructure and outcomes, public safety, economic prosperity, and infrastructure quality (McCann 2018). Each of these six sub-indices is made up of several variables; for example the economic prosperity index includes unemployment, underemployment, household income, and more.

This thesis does not use the final "Best- & Worst-Run Cities" outcome of the Wallethub project, but does use the six sub-indices to perform an initial exploratory data analysis of factors that may be influencing the rate of bike lane construction. Like the Walk Score[®] data it is nationally comparable and simple for researchers to use. However, the complexity of each one of the individual sub-indices makes it difficult to determine which of the many variables that make up each one is actually meaningful for infrastructure construction rates. Instead it is useful as a first step to help look for broad patterns, and later could be decomposed into individual variables.

2.4 Literature review summary

Literature on the different factors that might affect the ability of cities to implement their transportation plans uses a wide variety of methods. Plan implementation literature stems in large part from the

Pressman/Wildavsky (1973) and Bardach (1977) books that outline general trends and processes. Some of these have been extended to explore the specific question of transportation plan implementation and even more specific topics such as the implementation of bus rapid transit lines. The researchers and organizations described in this literature review have used both qualitative and quantitative methods, particularly case studies and regression. Many of them also administered surveys to collect data from policymakers and members of the public, not just organizations like NACTO and PeopleForBikes but also individual researchers. Relevant scholars cover this topic in the English language across the globe, but especially in the United States, Europe, and Latin America. Although there is a substantial body of research on topics such as bikeshare systems and bicycle lane design being published by researchers in China, there is a notable lack of literature available in the English language on the planning-related subjects relevant to this thesis. The NACTO and PeopleForBikes datasets and reports seem to be the most relevant sources that cover the implementation of citywide bicycle plans. But the work produced by researchers is useful for context, for identifying important variables, and for comparing different quantitative research methods.

3 Methodology

This thesis is a quantitative exploratory analysis of factors that may be associated with the pace at which bicycle network plans are being implemented in American cities. It explores what factors accelerate, slow, or have little effect on rate at which cities are building out their bike plans. The analysis begins with measuring the rate at which bike lanes are being built and continues by combining those rates with different factors to study how the different factors are associated with bike lane growth rates. The goal is to perform an exploratory longitudinal data analysis that uses results from each individual city to study factors that may be meaningful at a national level.

3.1 Tracking Implementation

Measuring the ability of a city to build out its bike plan is the task that makes the rest of the project possible. As discussed in the Literature Review, secondary data from groups like the Alliance for Walking and Bicycling already provide information on transportation plan implementation based on a survey sent to staff at different cities (The Alliance for Biking and Walking 2016). This thesis takes the responses contained in these datasets, verifies them for internal validity, and then calculates the compound annual growth rate (CAGR) in the bike network for each city as the main dependent variable.

3.1.1 Establishing definitions

On-street bicycle infrastructure is just one of many kinds of transportation facilities that cities and their partners provide to the public. This thesis is grouping *all* types of on-street bicycle lanes, regardless of cost, difficulty of construction, and perceived quality by the user. The four images in Figure 2 show examples of bike lanes that make up the “on-street bike lanes” being measured in the compound annual growth rate metrics described in this methodology section. These differ greatly in many design and implementation aspects, but all are counted equally.

Figure 2: Sample types of bike lanes that are included in this study.



(a) A congested, low quality, and inexpensive on-street bike lane. Photo by author, Somerville, MA



(b) A higher quality yet still inexpensive quick-build separated bike lane. Photo by author, Portland, OR



(c) A higher quality, moderately expensive parking-protected bike lane with dedicated signals. Photo by author, New York City, NY



(d) An expensive but top quality, parking-protected and grade separated cycle track with dedicated signals. Photo by author, Boston, MA

Similarly, the images in Figure 3 show the kinds of bicycle infrastructure that are not included in the definition of on-street bike lanes included in the compound annual growth rate calculations. The examples include shared-lane markings (perhaps better known as sharrows), neighborhood greenways, multiuse paths, and shared bike/bus lanes. Multiuse paths and trails are a high-quality infrastructure type often used by cyclists, but in many cities these are planned and managed by other agencies, such as county governments or parks districts. This introduces issues with jurisdiction that are difficult to

manage in a national-scale study. In addition, multiuse paths are much more expensive to develop and maintain than on-street bike lanes, leading to slower rates of development and lower likelihood of showing significant change over time compared to bike lanes.

Figure 3: Sample types of other bicycle infrastructure that are not included in this study.



(e) A shared-lane marking, commonly known as a sharrow, located on a street open to all traffic. Photo by NACTO, location unknown.



(f) A higher quality neighborhood greenway with wayfinding signage and physical traffic calming that permits all users. Photo by author, Seattle, WA



(g) A multiuse path that restricts motor vehicle traffic. Photo by author, Seattle, WA



(h) A shared bus/bike lane that restricts other users. Photo by TransitCenter, Everett, MA

3.1.2 Alliance for Biking and Walking survey data

The Alliance for Biking and Walking survey data is available on a generally biennial basis from 2002 to 2018 (League of American Bicyclists 2018). The most recent dataset release is from 2016, but published values from the 2018 *Bicycling and Walking in the United States: 2018 Benchmarking Report* were transcribed into a new dataset for this thesis. The Alliance surveys 69 American cities including 50 of the largest cities and 19 smaller and mid-sized cities such as Davis, California and Missoula, Montana, that are positioning themselves as regional or national leaders in providing bicycle infrastructure. The complete list of cities represented in the data set is included in this thesis as Appendix A.

In its printed form, the survey that is sent out to cities is 23 pages long with over 120 questions; an alternative minimum benchmarking survey is available for cities that are unable or unwilling to respond to the main survey (League of American Bicyclists 2018). This minimum survey is 3 pages long with 18 questions and was used by 10 cities in the *2018 Benchmarking Report*, but still includes the questions on bike lane inventory necessary to complete this thesis. The survey is used for a number of purposes, such as research, general benchmarking, and calculating recipients of the Bicycle Friendly City and State awards (League of American Bicyclists, 2018). The 2018 version of the full and minimum surveys are included as Appendix B.

The question on the survey used to gather the bike lane mileage used in the calculations for this thesis is reproduced in Figure 4 below:

Figure 4: Question used to gather the bike lane mileage used in this thesis. Image credit: League of American Bicyclists

****B16A1.** On streets with posted speeds of \leq 25mph, how many miles of each of the following bicycle facilities are there that meet or exceed current AASHTO or NACTO standards? (Answer in centerline miles. Write “o” if facility is not present in community.)

- Bike boulevards (# only)
- Shared lane markings (not counted under Bicycle Boulevards) (# only)
- Wide paved shoulders (ridable surface \geq 4 feet, and minimum clear path of \geq 4 feet between rumble strips) (# only)
- Bike lanes (incl. standard, contra-flow, left-side) (ridable surface \geq 4 feet) (# only)
- Buffered bike lanes (# only)
- Protected bike lanes (one-way or two-way) (# only)
- Raised cycle tracks (one-way or two-way) (# only)

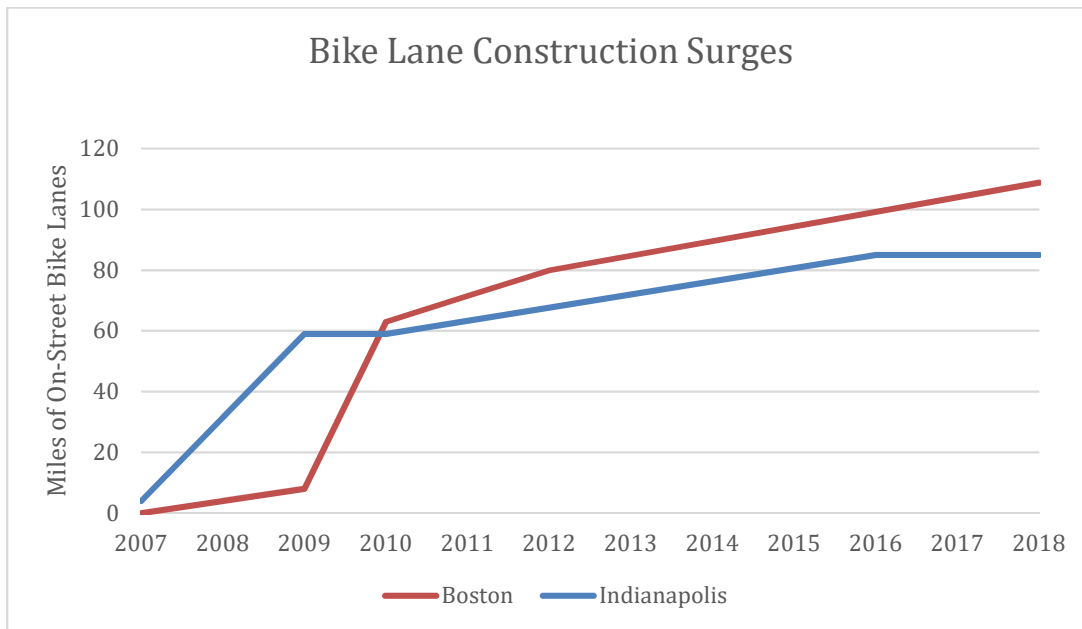
The question is repeated for streets with speed limits of 25-35 mph and again for streets with $>$ 35 mph speed limit. This allows researchers interested in correlations between speed limits and infrastructure types to perform their work, but the totals for all three questions across the different speed limits are summed for the purposes of this thesis. The totals for bike lanes, buffered bike lanes, protected bike lanes, and raised cycle tracks are also summed to a generalized “bike lane” total for the purposes of this thesis. While the question now specifies centerline miles, some cities have not always adhered to this specification as will be discussed further.

3.1.3 Selecting a metric for bike lane growth

This thesis aims to compare cities’ abilities to sustain bike lane construction over many years, but when the Alliance for Biking and Walking began administering their survey in 2007, some cities already had some amount of bike infrastructure, whereas others did not. Bike infrastructure was present in America’s largest cities, in progressive cities that were already seen as leaders in active transportation, and in new Sun Belt cities with room to spare on their roads. But other cities had no or very few bike

lanes, and so began their bike networks from scratch. Boston reported 0 miles of bike lanes, and Indianapolis reported only 4 miles in the late 2000s. As time passed, design advanced, and federal stimulus money became available, many of these cities rapidly grew their networks in the span of just a few years during the Great Recession. For example, Boston and Indianapolis grew to 63 and 59 miles, respectively by 2010. However, the remaining quickly-growing bike networks slowed down after the “low-hanging fruit” projects of road diets and key corridors were completed, and so simple linear annual average percent change calculations values in excess of 100% do not truly represent the sustained progress these cities have made on their transportation plans. Instead a linear annual percent change calculation would highlight the one-time surge in construction, as shown in the initial increases between 2007 and 2010 and subsequent plateau or slower growth as shown in Figure 5 below:

Figure 5: Bike lane construction rates in Boston and Indianapolis



Instead of a linear percent change calculation, which is not robust against brief periods of rapid change, this thesis uses the compound annual growth rate metric that attempts to correct for this issue.

Compound annual growth rates (CAGR) are often used by the financial and business communities for

precisely this reason, as they help avoid overstating sustained growth based on a year or two of intense growth.

The dozens of cities that participate in the survey vary in size and population, from Jacksonville's 747 square miles to Davis' 9.9 square miles, and from New York's 8.4 million people to Burlington's 42 thousand. This makes using raw mileage figures difficult and understates the amount of growth that was achieved in cities that are smaller in both size and population than others. Because of this, the CAGR calculation uses a percent change formula rather than a formula that uses raw mileage totals. This normalizes the scales at which different cities are building out their plans by reducing the effect of city size; a geographically compact city like Boston will have to build fewer miles of bike lanes to complete its transportation network compared to a large city like Chicago.

CAGR also accounts for the fact that different cities began their networks in different years and so some cities may only have three years to evaluate compared to other cities with decades of implementation history. Application of CAGR makes it possible to compare cities such as Kansas City, MO that were starting with nearly no bike infrastructure to cities such as Portland, OR, which already had decades of implementation. This method is also able to account for missing data — some cities failed to respond for one or more years or only joined the survey after 2007, which makes an approach that tracks implementation from year to year challenging. Finally, CAGR reduces the impact of the fact that some cities reported their infrastructure in lane-miles and some report centerline-miles, and so simply comparing mileage across cities in absolute terms would overstate growth in cities that report lane-miles.

To make comparison possible accounting for the issues described above, the actual mileage figures reported by each city were converted to CAGR using the equation:

$$CAGR = \frac{M_n^{\frac{1}{n}}}{M_1} - 1$$

where M_n = final year mileage, M_1 = beginning year mileage, and n = number of years between beginning and final years.

3.1.4 Supplemental sources and quality issues

A few cities changed their reporting format once or even twice, making it difficult to track growth within those cities. The Alliance for Biking and Walking only began to specify that they wanted centerline reporting in 2016 after nearly a decade of not specifying the format, and so acknowledges that raw mileage comparisons between cities in the past is impossible (League of American Bicyclists, 2018).

Accounting for missing years and changing data formats described above, the Alliance for Biking and Walking data ultimately proved to be usable for 56 out of the 69 cities contained in the dataset. In order to include the remaining cities, consultation of planning documents and inventories released by city officials was performed, as documented in Table 1 below:

Table 1: Cities Where Survey Data was Replaced

City	Alternative Data Source
Austin	Proposed Zach Scott St Improvements, 2018
Bellingham	Transportation Reports on Annual Mobility (TRAM), 2019
Burlington	PlanBTV Walk Bike, 2017
Charlotte	Transportation Action Plan, 2017
Davis	City of Davis Bicycle Plan, 2009
Fresno	Active Transportation Plan, 2016
Houston	Houston Bike Plan, 2017
Mesa	Bicycle Master Plan, 2018
San Diego	Bicycle Master Plan, 2013

For some cities such as Davis, only one year in the CAGR calculation needed to be replaced. For other cities such as Fresno, all survey data was discarded and replaced with mileage figures from the city's

own planning documents. No usable data were available online for Charleston, Jacksonville, Miami, San Antonio and so these cities are excluded from this thesis resulting in a final total of 65 cities. Recent planning documents from Jacksonville note that their bicycle infrastructure inventory is of poor quality and are thus unreported; the remaining cities either did not report historical figures for the start year in the CAGR calculation or did not separate their bike lane mileage from sharrows, bike paths, and other infrastructure types pictured in Figure 3 in the Definitions section above.

3.2 Variable Selection

The current project relies on the combination of the bike lane inventory data described above with data representing attributes that may be related to implementation of that city's plans. The list below is based on the Literature Review discussed above and the author's experience with transportation planning at the municipal and federal levels. It is clear from existing literature that many factors could be associated with the rate at which cities can build out their transportation plans. This project aims to study which factors are associated with differential rates of compound annual growth rates of bike lanes and the strengths of these associations. Several factors that are hypothesized to have no association are included as well in order to test that this null hypothesis is valid.

Although some factors hypothesized to affect plan implementation could not be included in this thesis, forty-three different factors were ultimately compared against CAGR. The factors are organized into themes: political, economic, implementation, general transportation, cycling, weather, and city-specific factors, such as the city's size. It may be worth noting that this method of organization is somewhat arbitrary and is done here for organizational purposes – a factor like income inequality is included with the economic grouping of factors but different schools of thought would link it to political decisions or traits inherent to a city and its people.

3.2.1 Political factors

Political factors affect how decision makers choose to implement projects called for in the bicycle network plan. Transportation planners in the United States work within and are ultimately answerable to political systems that are in turn answerable to voters. Engaging in transportation projects more complex than routine filling of potholes and restriping of faded road markings is a political decision, and one can expect that different political environments are more or less conducive to building bicycle infrastructure.

The transportation network plans that are the focus of this thesis are typically written by city staff and consultants, but then approved by each particular city's legislative and executive bodies.

Implementation is also a political process, either formally or informally. A few cities, including Chicago, have a political system in which city legislators can formally intervene to advance, modify, or halt specific projects. But most cities rely on more informal political processes with legislators and the executive being able to exert pressure in order to advance to slow transportation projects. Measuring the subtleties of the differences in these systems is a challenge, and so this thesis tests a number of different political factors that could be at work in influencing the rate at which cities build out their bike lane network. Table 2 shows the political factors considered for each city, including the data type, source, and the hypothesized relationship with acceleration of plan implementation:

Table 2: Selected political factors

Political Factor	Type	Data Source	Expected relationship with CAGR
Count of bicycle and pedestrian advocacy groups (Total)	Continuous	Alliance for Walking and Biking survey data	More groups accelerates plan implementation
Count of bicycle and pedestrian advocacy groups (Residents per Group)	Continuous	Alliance for Walking and Biking survey data	More groups accelerates plan implementation
Presence of a bicycle advisory board or committee	Dichotomous	Alliance for Walking and Biking survey data	No significant effect
Successful passage of a Complete Streets ordinance or executive order	Dichotomous	Alliance for Walking and Biking survey data	Accelerates plan implementation
Year of passage of a Complete streets ordinance or executive order	Continuous	Alliance for Walking and Biking survey data	Older policies accelerate plan implementation
NACTO membership	Dichotomous	Alliance for Walking and Biking survey data	No significant effect
Count of mayors during study period	Continuous	Wikipedia and Ballotpedia	More mayoral turnover slows plan implementation

3.2.2 Economic factors

Economic factors are related to the overall funding environment in which city planners work. Regardless of political will and structure, it takes money to repave streets, install signposts, and reconfigure traffic signals. Thus one can expect that economic factors can enable even a wealthy city with lukewarm political support for bike infrastructure to build at a rate that matches an enthusiastic city in a more challenging economic situation.

The economic factors described below in Table 3 mix the direct amount of funding expended on building bike infrastructure, the overall fiscal health of city government, as well as the economic success of its residents and business community. Unfortunately, the actual per-mile or per-project costs per city were

unavailable for enough cities for this to be a meaningful factor for study, although they can be hypothesized to have a very strong negative association with CAGR where higher costs result in slower implementation.

Table 3: Selected economic factors

Economic Factor	Type	Source	Hypothesis
Amount of bicycle and pedestrian investment funding	Continuous	Alliance for Walking and Biking survey data	More funding accelerates plan implementation
Per capita bicycle and pedestrian investment	Continuous	Alliance for Walking and Biking survey data	More funding accelerates plan implementation
Presence of a bicycle and pedestrian investment target or mandate	Dichotomous	Alliance for Walking and Biking survey data	No significant effect
Percent of residents below poverty line	Continuous	Alliance for Walking and Biking survey data	Higher poverty levels slows plan implementation
Gini Index	Continuous	Brookings Institution	Higher inequality slows implementation
City government financial index	Continuous	Wallethub indexing	A healthier government implements faster
City economic index	Continuous	Wallethub indexing	A wealthier populace accelerates plan implementation

3.2.3 Implementation Factors

Implementation factors are directly related to the transportation planning environment within each city. The list shared in Table 4 below includes one factor for the initial size of the bike network at the start of each study period and one factor measuring the size of the team at each city responsible for planning, building, and maintaining the bike network. It also includes a composite infrastructure index ranking compiled by Wallethub from several component factors such as road pavement condition.

Table 4: Selected implementation factors

Implementation Factor	Type	Source	Hypothesis
Initial size of bike network (miles)	Continuous	Alliance for Walking and Biking survey data	Cities with a smaller initial network implement faster
Bicycle and pedestrian staff per capita	Continuous	Alliance for Walking and Biking survey data	More staff leads to faster implementation
City infrastructure index	Continuous	Wallethub Indexing	Cities with a higher infrastructure score are more likely to implement faster

3.2.4 Transportation factors

No transportation mode operates in a vacuum; researchers such as Marshall and Ferenchak (2019) have demonstrated that bike lane implementation results in safety improvements for other road users as well. The three factors in Table 5 are used to characterize the non-cycling transportation environment within a city to search for associations between other transportation modes and the rate of bike lane implementation. The proprietary Walk Score® and Transit Score® measures are compiled by Redfin’s Walk Score® group as a general measure of the reach and quality of a city’s pedestrian and transit network. The percent of households without access to a vehicle is also included to show how accessible private vehicles are to a city’s residents and to measure car ownership.

Table 5: Selected transportation factors

Transportation Factor	Type	Source	Hypothesis
Walk Score®	Continuous	Alliance for Walking and Biking survey data	No significant effect
Transit Score®	Continuous	Alliance for Walking and Biking survey data	No significant effect
Percent of households with no vehicles	Continuous	Alliance for Walking and Biking survey data	Cities with more people without cars are faster to implement their bike plans

3.2.5 Bicycle factors

The cycling-related factors in Table 6 below capture the popularity, quality, reach, and growth of cycling within the different cities included in this study. Factors include a mix of different sources to account for the availability of services like bikeshare, the rate at which bike commuter rates are growing or falling, and more. These factors can help identify whether cities that already have high quality cycling amenities are in turn building faster to build on their past success, or if cities that lack these amenities are responding to this gap by building rapidly. This could help test whether there is a positive feedback loop where cities accelerate construction they build out their bike lane networks or if progress slows once they begin to see success.

Table 6: Selected bicycle factors

Bicycle Factor	Type	Source	Hypothesis
Bike Score®	Continuous	Alliance for Walking and Biking survey data	Cities with already high Bike Scores® implement their plans more slowly
Change in bike commuter rate	Continuous	Alliance for Walking and Biking survey data	Growing levels of bike commuting leads to faster implementation
Percent of bike commuters who identify as female	Continuous	Alliance for Walking and Biking survey data	Higher share of women who commute by bike leads to faster implementation
Safety Score	Continuous	PeopleForBikes City Rankings	Worse safety rankings are associated with slower implementation
Perceived bike safety	Continuous	PeopleForBikes City Rankings	Worse safety perceptions are associated with slower implementation
Perceived quality of recreational cycling	Continuous	PeopleForBikes City Rankings	Better recreational riding quality is

			associated with faster implementation
Presence of a bikeshare system	Dichotomous	Alliance for Walking and Biking survey data	Cities with bikeshare build faster than cities without
Type of bikeshare system	Nominal	Alliance for Walking and Biking survey data	Cities with fixed bikeshare build faster than cities with dockless or no bikeshare

It should be noted that the final factor in Table 6 has two possible levels – fixed bikeshare is the traditional type where users rent and return bicycles from dedicated stations located throughout the city. Dockless bikeshare is newer and allows users to rent and return bicycles to any point that they wish. Fixed-station bikeshare has its origins in the early 2000s in Europe, and dockless bikeshare only began in its modern form in China in 2016. Both are now common in American cities, and examples are pictured below in Figure 6, although the number of dockless bikeshare systems appears to be rapidly falling as of the Spring of 2019.

Figure 6: Types of bikeshare systems



An example of two fixed-station bikeshare systems in Portland, OR. Photo by author.



An example of dockless bikeshare bikes in Seattle, WA. Photo by author.

3.2.6 Weather and climate factors

These weather and climate factors shown in Table 7 directly affect the ability of cities to support year-round building of bicycle infrastructure. For example, working with asphalt and concrete becomes much more challenging at temperatures below 50 degrees Fahrenheit, and is nearly impossible below freezing. High temperatures or high levels of precipitation can be hypothesized to slow down construction due to their effects on labor and materials as well.

Table 7: Selected weather and climate factors

Weather Factor	Type	Source	Hypothesis
Average number of days with minimum temperature below freezing	Continuous	Alliance for Walking and Biking survey data	Cities with more cold days are slower to implement their plans
Average number of days with maximum temperature below freezing	Continuous	Alliance for Walking and Biking survey data	Cities with more very cold days are slower to implement their plans
Average number of days with maximum temperature above 90° F	Continuous	Alliance for Walking and Biking survey data	Cities with more hot days are slower to implement their plans
Average annual precipitation (inches)	Continuous	Alliance for Walking and Biking survey data	Cities with more precipitation are slower to implement their plans

3.2.7 City-specific factors

Urban form and demographic factors function as control variables and as ways to measure traits specific to each city that could act as facilitators or barriers to the implementation of bicycle plans. A bicycle plan will never meaningfully change the median age of residents or the physical size of the city, but an older populace or a larger city could certainly slow its implementation. These factors include a mix of variables that describe a city’s urban form and the people who live and work in it.

Table 8: Selected city-specific factors

City-Specific Factor	Type	Source	Hypothesis
City area (square miles)	Continuous	Alliance for Walking and Biking survey data	No significant effect
Population	Continuous	Alliance for Walking and Biking survey data	No significant effect
Density (people per square mile)	Continuous	Alliance for Walking and Biking survey data	Denser cities are slower to implement their plans
Population growth	Continuous	Alliance for Walking and Biking survey data	Faster growing cities are slower to implement their plans
Presence of a legacy transit system or pre-auto urban form	Dichotomous	Wikipedia	Cities with more constrained right-of-way are slower to implement their plans
Median age of residents	Continuous	Alliance for Walking and Biking survey data	Younger cities are faster to implement their plans
Percent non-white and/or Hispanic	Continuous	Alliance for Walking and Biking survey data	No significant effect
City's region within the United States	Nominal	US Census	Northeastern and Southern cities implement slower than Midwestern and Western cities
Education index	Continuous	Wallethub indexing	Cities with a more educated populace implement faster
Health index	Continuous	Wallethub indexing	Cities with a healthier populace implement faster
Public Safety index	Continuous	Wallethub indexing	No significant effect

3.2.8 Data management and collection

Data were compiled in tabular format, with cities as rows, compound annual growth rates in the bike lane network as a column, and the different factors as additional columns. Most of the factors described above were available in compiled form from the noted data sources, and only a few required manual

compilation. Some of the factors, such as demographic and economic information from the US Census and Bureau of Labor Statistics, were not obtained directly from these sources, but were obtained as part of other data sets, such as the Alliance for Walking and Biking. Despite this wealth of data, manual data collection was required for a few factors to complete the project. For example, there is no easily workable dataset for mayoral turnover and so this was manually created for this thesis by pulling from Wikipedia and Ballotpedia.

3.3 Statistical Analysis

This project used statistical methods such as regression to perform an exploratory data analysis to see how the factors listed above are associated with the rate of bike lane implementation. All analysis was conducted using R version 3.6.0 within the R Studio integrated development environment on a Microsoft Windows PC. The methods used varied depending on the nature of each of the factors that was compared against CAGR. Categorical factors were examined using statistical tests and continuous factors were examined using correlation tests and regression. For the purposes of this study, “statistical significance” was defined as a p-value of 0.05.

3.3.1 Statistical Tests for Categorical Factors

The next step was to use various tests to see whether there are significant differences between the different levels of categorical factors and the rate at which cities are building out their bike lane networks. These categorical factors are ones where there are only a few possible values, such the region of the country a city belongs to. This thesis makes use of either the Wilcoxon test or the Kruskal Wallis test to see whether or not the differences between cities are most likely artifacts of chance, or if they represent a meaningful difference. These non-parametric tests are an alternative to the more traditional t test and ANOVA test that are used here because they are more suitable for datasets such as this one that do not have an approximately normal distribution. The Wilcoxon test is used when there are only

two possible values (such as presence or absence of a policy), and the Kruskal Wallis test is used when there are more than two possible values (such as the US Census' definitions of different geographic regions within the United States).

3.3.2 Correlation Testing and Univariate Regression for Continuous Factors

The final step in the project was to use correlation testing and regression on the continuous factors that are represented by a range of numbers in order to identify any associations that may exist with CAGR.

The correlation testing method used is the Kendall rank correlation coefficient, as the non-normal distribution of the CAGR variable violates the normality assumption of the more traditional Pearson correlation method. Outputs from the Kendall test include the correlation coefficient displaying the strength and the direction of a linear relationship between each of the continuous factors and CAGR, and the p-value indicating the statistical significance of this result.

Regression techniques can further explore the relationships present between CAGR and the various continuous factors studied in this thesis. Of the statistical modeling techniques, classic linear regression is the preferred methodology for its ease of interpretation and its widespread use. The dependent variable measuring the different rates of bike lane construction is continuous, and only one dependent variable is of interest in each model. Linear regression can help answer two of the core research questions, whether each factor is associated with accelerating or decelerating plan implementation (the coefficient estimate) and whether or not that relationship is statistically significant (the p-value). A polynomial/quadratic regression and a generalized additive model (GAM) are also used on occasion when there is an apparent non-linear relationship. While more challenging to interpret at a glance, these models better represent non-linear relationships. Locally estimated scatterplot smoothing (LOESS) is used with each continuous factor as a visualization tool. A small dataset such as this one is vulnerable to

overfitting with LOESS and so it is used only to visually trace relationships rather than to establish associations.

4 Results

It is clear from the existing literature that many factors could be at play as influencers that affect the rate at which cities built out their transportation plans. This section describes the results of the procedures outlined above in the Methodology section.

4.1 Compound Annual Growth Rate Results

The CAGR results for each city are shared in Table 9, sorted from fastest to slowest implementation of bike lanes. The years covered in each city's study period are also included. The mean growth rate was 14%, with a median of 10%. Four cities reported no growth during the study period and so have a CAGR of 0%. None of the cities involved had a negative growth rate, where more miles of bike lane were removed than were installed.

Table 9: Bike Lane Annual Growth Rates by City

City	Compound Annual Growth Rate of Bike Lanes	Study Period
Detroit, MI	69.5%	2007-2012
Memphis, TN	48.0%	2009-2018
Anchorage, AK	47.0%	2012-2018
Arlington, TX	35.8%	2010-2018
Boston, MA	33.6%	2009-2018
New Orleans, LA	33.6%	2009-2018
Indianapolis, IN	32.0%	2007-2018
Raleigh, NC	30.3%	2009-2018
Albany, NY	29.4%	2012-2018
Mesa, AZ	28.6%	2012-2018
Columbus, OH	26.3%	2007-2018
Kansas City, MO	24.4%	2007-2018
Denver, CO	22.1%	2007-2016
Long Beach, CA	20.8%	2007-2018

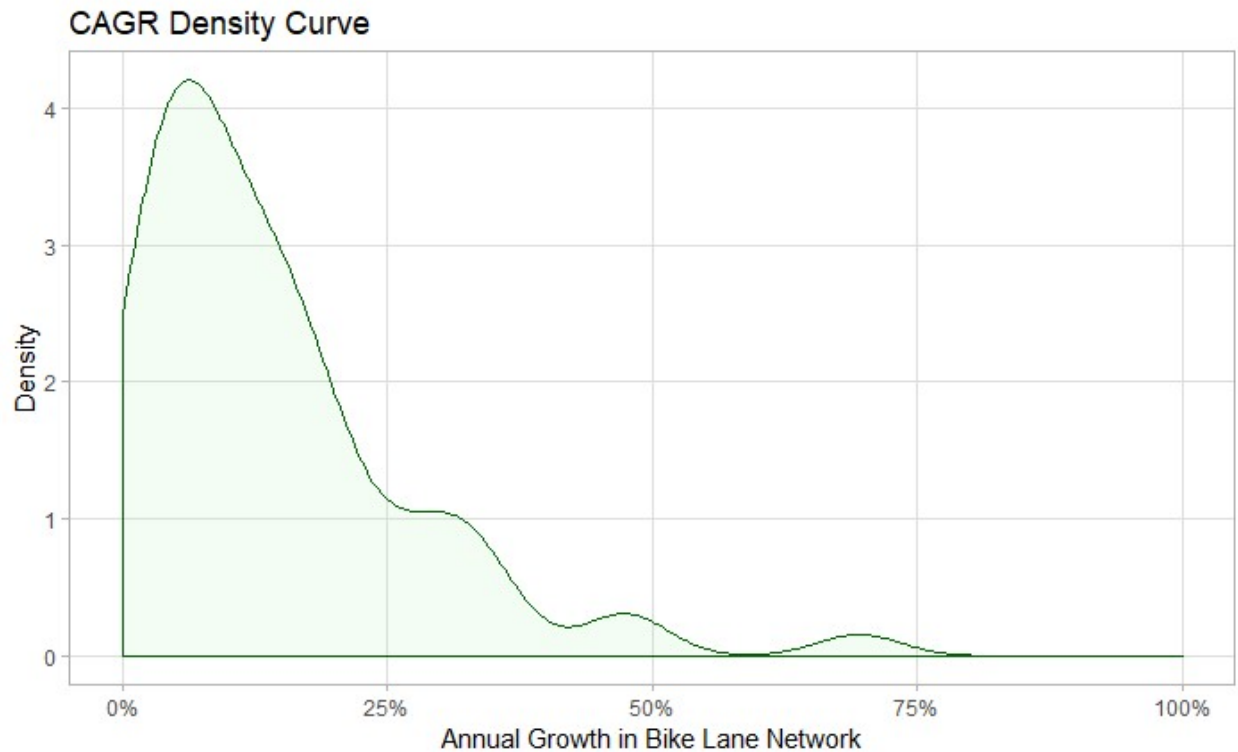
Fort Worth, TX	20.2%	2009-2018
Baltimore, MD	19.8%	2007-2018
Nashville, TN	18.8%	2007-2016
Oakland, CA	18.2%	2007-2016
Washington, DC	17.3%	2007-2016
Charlotte, NC	16.6%	2007-2018
Atlanta, GA	15.9%	2007-2018
Cleveland, OH	15.6%	2007-2018
El Paso, TX	15.1%	2010-2018
San Francisco, CA	14.8%	2007-2018
Minneapolis, MN	14.8%	2007-2018
Milwaukee, WI	13.9%	2007-2018
Seattle, WA	13.8%	2007-2018
Wichita, KS	13.7%	2012-2018
Louisville, KY	13.5%	2009-2016
Honolulu, HI	13.2%	2007-2018
Fresno, CA	11.4%	2010-2016
San Jose, CA	10.5%	2007-2018
St. Louis, MO	9.7%	2012-2018
Bellingham, WA	9.7%	2016-2018
New York, NY	9.3%	2007-2018
Colorado Springs, CO	8.7%	2007-2018
Tulsa, OK	8.7%	2007-2016
Salt Lake City, UT	8.7%	2012-2018
Virginia Beach, VA	8.5%	2007-2018
Philadelphia, PA	8.4%	2007-2016
Los Angeles, CA	8.2%	2007-2018
Austin, TX	7.1%	2007-2018
Houston, TX	6.7%	2012-2016
Phoenix, AZ	6.6%	2007-2018
Dallas, TX	6.5%	2012-2018
Albuquerque, NM	6.1%	2007-2018
Oklahoma City, OK	5.9%	2007-2018
Chicago, IL	5.7%	2007-2018
Tucson, AZ	5.1%	2007-2012
Pittsburgh, PA	4.1%	2012-2018
Missoula, MT	4.1%	2007-2017
Davis, CA	3.9%	2009-2018
Omaha, NE	3.8%	2007-2018
Eugene, OR	3.7%	2012-2018
Portland, OR	3.4%	2007-2018

Las Vegas, NV	3.1%	2013-2018
Sacramento, CA	2.7%	2009-2016
Fort Collins, CO	2.6%	2012-2018
Madison, WI	2.1%	2012-2018
Boulder, CO	1.8%	2012-2016
San Diego, CA	1.0%	2010-2018
Baton Rouge, LA	0.0%	2012-2018
Burlington, VT	0.0%	2012-2016
Chattanooga, TN	0.0%	2016-2018
Spokane, WA	0.0%	2016-2018

As a diagnostic measure, the number of years covered in each city’s study period were compared against the city’s compound annual growth rate of bike lanes using linear regression in order to see whether the lengths of the study periods could be introducing bias to the growth rates. The linear regression shows a very slight positive trend with a coefficient of 0.006, but this trend is not statistically significant given a p-value of 0.37.

Figure 7 below shows a graphic distribution of cities according to the annual growth in the bike lane network that they were able to sustain over time. The plot shows that the CAGR is positively skewed, with some cities achieving no growth, the largest number of cities managed growth from 5% to 15% per year, then rapidly declining to about 25% per year. The median growth achieved is 10%, but the high-performing cities that create a long tail to the right of the distribution bring the mean annual growth to 14%. Cities achieving more than 15% CAGR can be said to be high-performing in their plan implementation, and cities achieving less than 5% can be considered low-performing. It is clear based on a visual inspection of the plot above that CAGR is not normally distributed.

Figure 7: CAGR Density Curve



4.2 Statistical Tests on Categorical Factors

Several of the variables of interest are categorical variables, where each city has or doesn't have a trait. For example, a city could have a bikeshare system, or be in a Southern state, or have a Complete Streets policy. These cannot be represented numerically, and so the four tests outlined in the Methodology section are used here.

4.2.1 Political factors

The results for the categorical political factors are displayed below in Figure 8. There is no significant relationship between a city's membership in NACTO or its passage of a Complete Streets policy and the rate at which it is able to implement its bike lane network plan. The political factor of whether a city has an advisory committee or other official means for citizens to advise their city in the implementation of

their bicycle plan was not investigated further because only three cities reported that they lacked such a body, and so the chances of finding meaningful differences are slim.

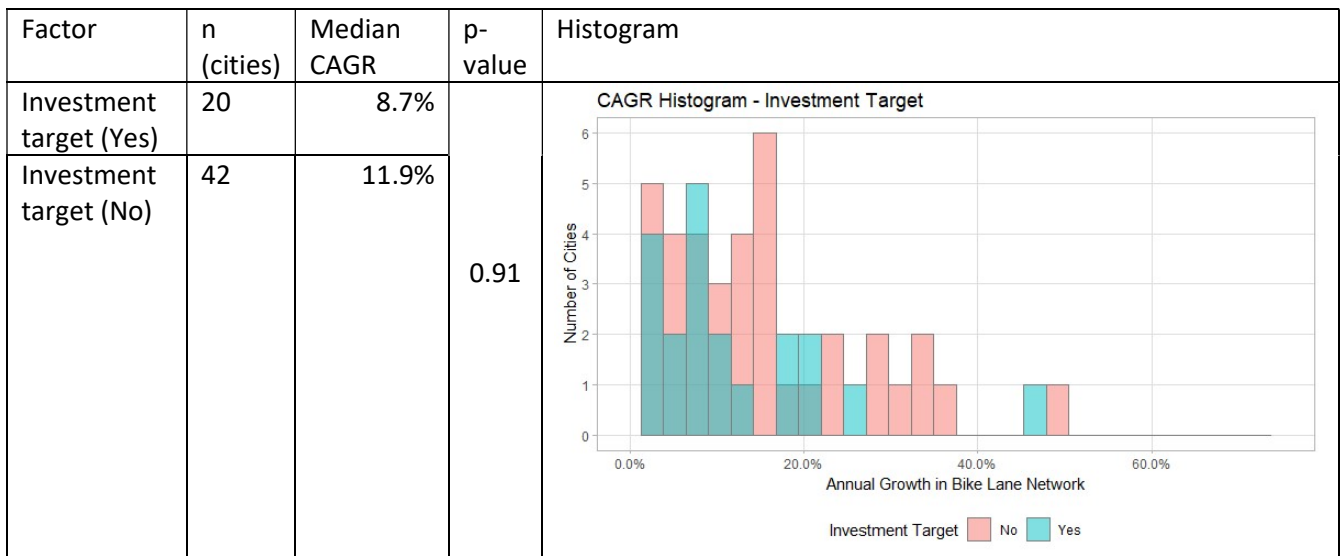
Figure 8: Categorical political factor results

Factor	n (cities)	Median CAGR	p-value	Histogram
NACTO membership (Yes)	37	14.7%	0.72	<p>CAGR Histogram - NACTO membership</p>
NACTO membership (No)	28	13.6%		
Complete Streets policy (Yes)	52	9.7%	0.80	<p>CAGR Histogram - Complete Streets Policy</p>
Complete streets policy (No)	13	10.5%		

4.2.2 Economic factor

The results for the sole economic categorical factor of whether or not a city has a target for annual or total investment in its bicycle and pedestrian infrastructure are shared in Figure 9 below. There is no significant relationship between a city’s presence or absence of an investment target and the rate at which it is able to implement its bike lane network plan.

Figure 9: Economic categorical factor results

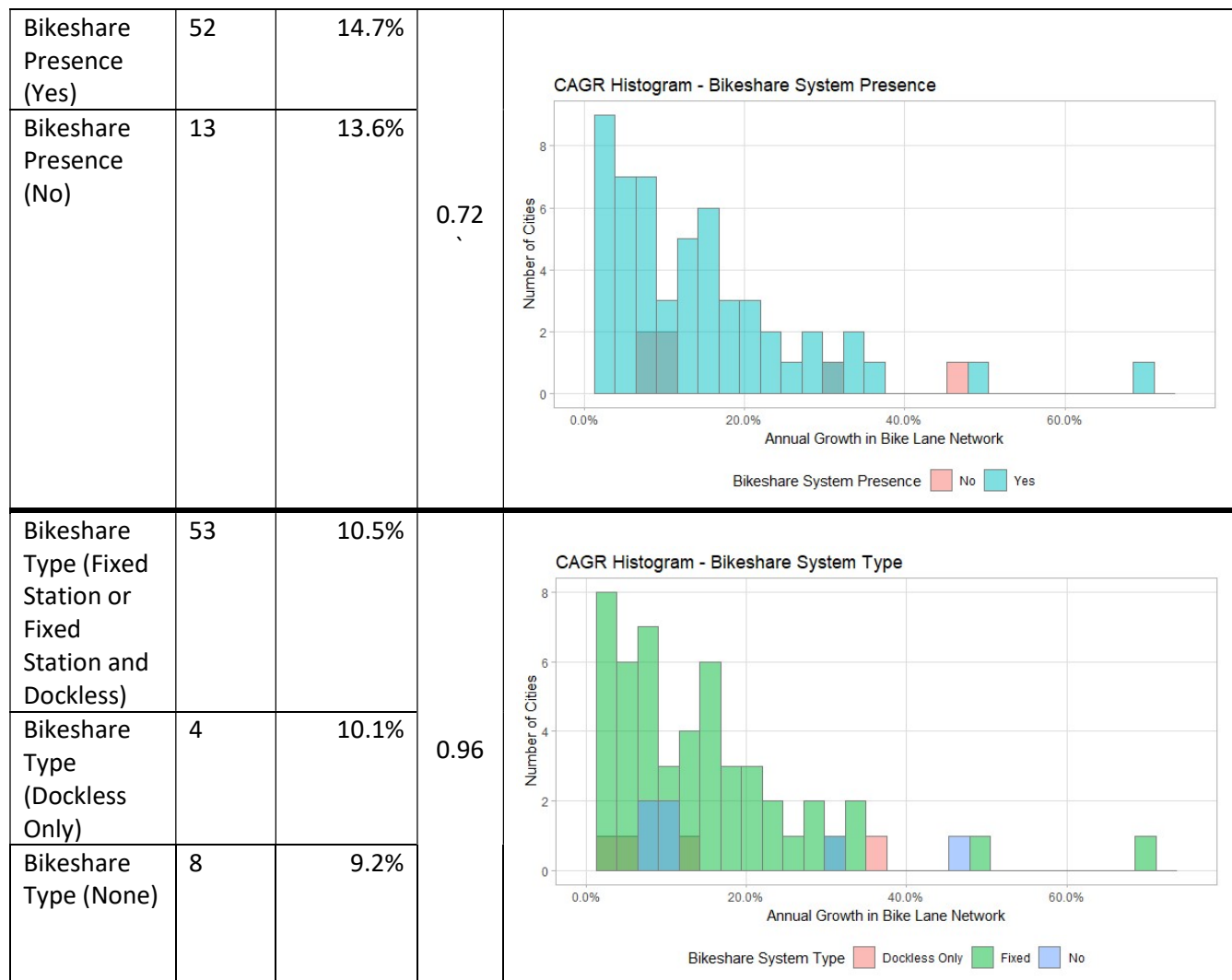


4.2.3 Bicycle factors

The results for the categorical bicycle factors are included as Figure 10 below. There is no significant relationship between a city’s having a bikeshare system or the type of bikeshare system and the rate at which it is able to implement its bike lane network plan.

Figure 10: Categorical bicycle factor results

Factor	n (cities)	Median CAGR (%)	p-value	Histogram

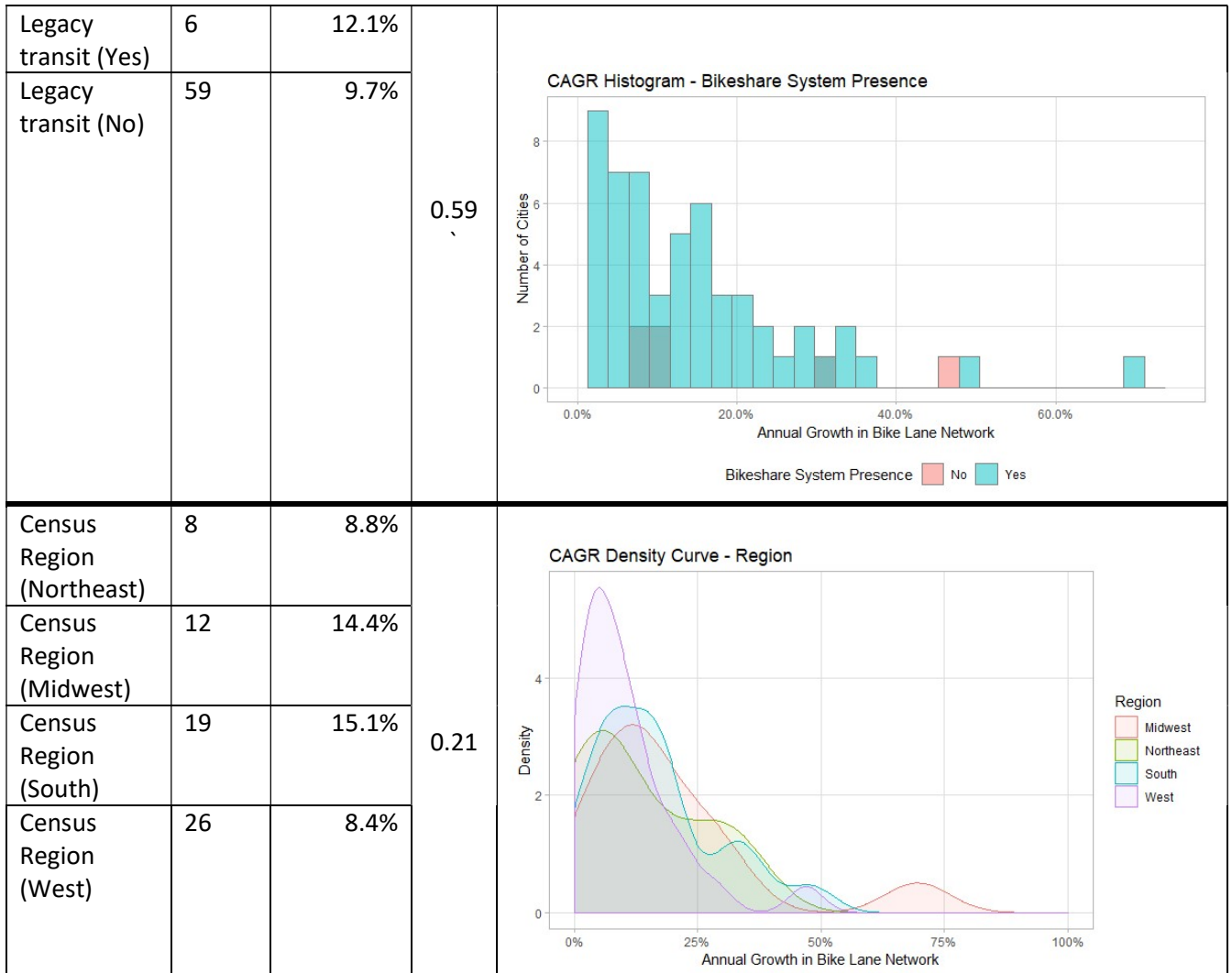


4.2.4 City-specific factors

The results for the categorical bicycle factors are included as Figure 11 below. There is no significant relationship between a city’s having a legacy transit system or the city’s region within the United States and the rate at which it is able to implement its bike lane network plan.

Figure 11: City-specific factor results

Factor	n (cities)	Median CAGR (%)	p-value	Plot
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4.3 Statistical Tests on Continuous Factors

Many of the factors that might be responsible for the different growth rates of the bike lane networks in American cities are continuously variable numeric factors. Table 10 below shares the results of an initial Kendall correlation test between each variable and CAGR.

Table 10: Kendall's Rank Coefficient of Correlation results for continuous factors

Factor	Coefficient	P-Value	Number of Cities
Count of Advocacy Groups	-0.074	0.424	65

Advocacy Groups (Residents Per Advocacy Group)	0.133	0.13	61
Year of Complete Streets Policy Adoption	0.111	0.264	51
Number of Mayors during Study Period	-0.128	0.382	29
Proportion of Residents below the Federal Poverty Line	0.105	0.228	65
Economy Index	0	1	58
Financial Stability Index	-0.001	0.995	58
Bike/Ped Funding (Total)	-0.036	0.74	44
Bike/Ped Funding (Per Capita)	-0.118	0.269	43
Inequality (Gini)	0.136	0.157	52
Bike/Ped Staff (Per 100k Residents)	-0.082	0.371	58
Infrastructure Ranking	0.198	0.028	58
Initial Mileage of Bike Lane Network	-0.492	0	63
Proportion of Households with No Vehicle	-0.042	0.639	65
Transit Score	0.088	0.41	42
Walk Score	0	1	65
Bike Safety Points	-0.019	0.838	65
Growth in Bicycle Commuters	0.011	0.9	65
Bike Score	-0.179	0.053	55
Perception of Safety	0.07	0.433	63
Recreational Riding Quality	-0.106	0.235	65
Women Bike Commuters	-0.103	0.226	65
Average Precipitation (Inches)	0.139	0.103	65
Days over 90 degrees	-0.026	0.764	65
Days with a Maximum Temperature Below Freezing	0.051	0.555	65
Days with a Minimum Temperature Below Freezing	0.009	0.919	65

Population Density	0.014	0.87	65
Education Index	0.098	0.277	58
Health Index	0.122	0.175	58
Median Age of Residents	-0.144	0.092	65
Non-white and/or Hispanic Proportion	-0.043	0.614	65
Total Population	0.158	0.063	65
Population Change	0.073	0.404	65
Safety Index	0.041	0.648	58
City Area (Square Miles)	0.086	0.311	65

Only the Wallethub infrastructure index and the initial mileage of the bike network have a significant relationship with CAGR where the p-value of the Kendall correlation test is below 0.05. Six other factors have p-values below 0.2 and are carried forward to a second stage of analysis. A further seven factors have a p-value above 0.2 but a visually apparent relationship when plotted against CAGR; these are also carried forward for a second stage of analysis to determine if they have non-linear relationships.

4.3.1 Significant and potentially significant factors

This section presents further analyses of the factors selected in the prior section for having a significant Kendall correlation or for having an apparent visual relationship. Each factor is displayed on a scatterplot where the compound annual growth rate of bike lanes is plotted on the y axis, and the factor being examined is plotted on the x axis. Each factor is compared against the compound annual growth rate alone, with no multiple regression or interaction terms.

4.3.1.1 Political

The residents per advocacy group within a city had a p-value of 0.13 in the Kendall test and was selected for further analysis. The year that a Complete Streets policy was adopted and the number of mayors has an apparent visual relationship with CAGR, and so these two factors are explored further in Figure 12.

Figure 12: Continuous political factors

Factor	Regression Coefficient	p-value	Plot
Residents per advocacy group	-0.000000005	0.94	
Year of Complete Street policy adoption	0.005	0.13	
Number of Mayors during study period	-0.056	0.13	

4.3.1.2 Residents per advocacy group

Visually it appears that cities with fewer residents per advocacy groups may be implementing their bike plans faster than cities with more residents per advocacy group. The LOESS model appears to show a modal distribution where cities with about 150,000 and 450,000 residents per advocacy group implement the fastest. The linear regression model reports a non-significant result with a nearly flat coefficient.

4.3.1.3 Year of Complete Streets policy adoption

Visually it appears that cities that implemented their Complete Streets policies from 2011-2013 are implementing their bike plans the fastest. Both early adopter and latecomer cities appear to be building out their bike lane network at a lower rate. The linear regression model reports a p-value of 0.13 which is below the conventional threshold for statistical significance. Given the visual non-linearity and the presence of San Francisco as the nation's first adopter of a Complete Streets policy, a polynomial regression was used as well with San Francisco removed. This results in a statistically significant result with a p-value just below 0.05 that shows a peak around 2012 similar to the visually apparent trend.

4.3.1.4 Count of Mayors

Count of mayors was used as a proxy for the complex concept of political stability. Most cities had two mayors during this time period, but enough cities with one, three, or four mayors exist in the database to allow the trend to be visually inspected. Cities without strong-mayor systems are excluded. Seattle, which technically had six mayors during the study period was removed as an outlier, as two of those mayors were brief caretaker mayors serving in the period between Mayor Ed Murray's resignation and the beginning Mayor Jenny Durkan's elected term.

A visual inspection suggests that more political turnover is associated with slower bike lane network expansion. However, this result is not statistically significant.

4.3.2 Economic continuous factor

Economic inequality was the sole economic factor that shows any sign of potential significance. Results for inequality are shared below in Figure 13.

Figure 13: Continuous economic factor

Factor	Regression Coefficient	p-value	Plot
Economic inequality (Gini)	0.009	0.17	

4.3.2.1 Inequality (Gini)

A visual inspection and the linear regression model show a positive association where more unequal cities may be implementing their bike lane plans slightly faster. The LOESS model adds an additional peak and trough but may be influenced by several outliers representing high-performing cities with moderate amounts of income inequality.

The linear regression model results in a p-value of 0.17, which decreases to 0.11 by removing Memphis and Detroit, two potential outlier cities that achieved an annual average growth rate of greater than

40%. Neither the full linear regression model nor the model with two potential outlier cities removed is significant at conventional levels.

4.3.3 Implementation

Figure 14 shows how two implementation factors are related to the compound annual growth rates of bike lanes within major American cities.

Figure 14: Continuous implementation factors

Factor	Regression Coefficient	p-value	Plot
Infrastructure index	.0009	.03	
Initial network size	-0.0005	0.0008	

4.3.3.1 Infrastructure index

A visual inspection of the Wallethub Infrastructure index appears to show little pattern. The linear model shows a positive association where cities with a relatively worse infrastructure ranking score are associated with faster rates of bike lane expansion.

A linear regression results in a significant p-value with a coefficient of 0.0009. The fact that this factor is an index comprised of many variables, such as pavement condition, congestion, and air pollution means that these component variables are worth decomposing into individual factors for a future study.

4.3.3.2 Initial mileage of the bike lane network

A visual inspection appears to show a negative relationship between the number of miles in a city's bike lane network at the start of each city's study period and the rate at which it is implementing its bicycle plans. In other words, cities with a smaller initial bike lane network implement faster than cities that already have an existing network. Both models show a negative association, with the LOESS model adhering closely to the visual scatterplot. It appears that the rate at which implementation is happening in cities slows down after a city has approximately 50 miles of their on-street bike lane network constructed. The linear regression model reports that this is a significant result, but a GAM or polynomial regression is better able to capture the visually apparent non-linear relationship.

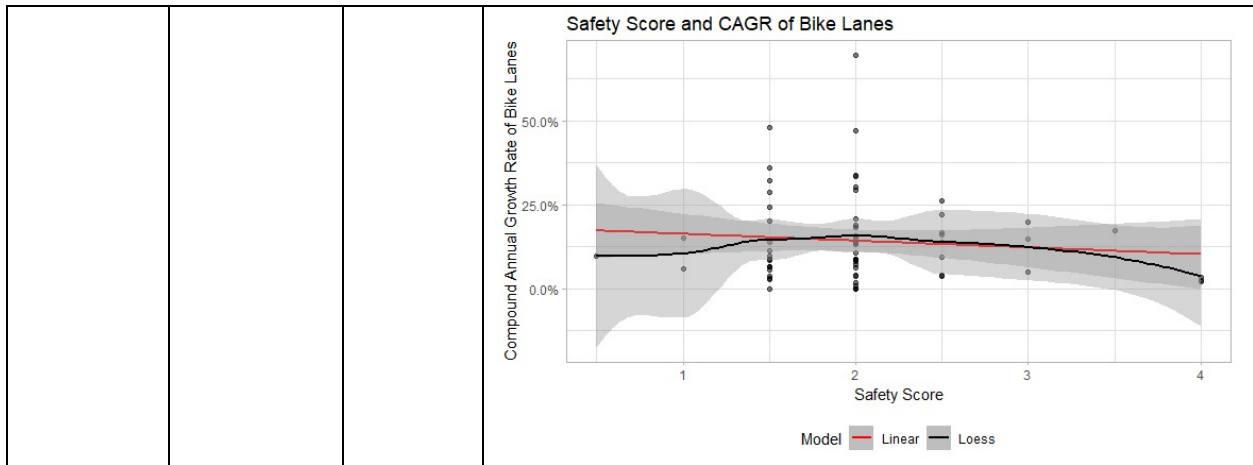
4.3.4 Continuous bicycle factors

Figure 15 below shows results for the continuous bicycle factors that showed some sign of a significant relationship.

Figure 15: Continuous bicycle factors

Factor	Regression Coefficient	p-value	Plot
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<p>Bike Score</p>	<p>-0.002</p>	<p>.09</p>	<p>Bike Score and CAGR of Bike Lanes</p>
<p>Growth in commute rates</p>	<p>-0.1</p>	<p>0.64</p>	<p>Growth in Bike Commuting and CAGR of Bike Lanes</p>
<p>Perception of safety</p>	<p>0.19</p>	<p>0.66</p>	<p>Perception of Safety and CAGR of Bike Lanes</p>
<p>Safety Score</p>	<p>-0.2</p>	<p>0.42</p>	



4.3.4.1 Bike Score®

The Bike Score® for each city appears to have a negative association with the annual growth of bike lanes in American cities, indicating that bike lanes are growing faster in cities with a worse Bike Score®. This negative relationship is visible in the regression model results. However, the linear regression model has a p-value of 0.09 which indicates that this result is not a significant finding.

4.3.4.2 Growth in Bicycle Commuters

A visual inspection of the relationship between the growth in the proportion of bike commuters out of all commuters within American cities between 2010 and 2016 shows no clear relationship with the growth of bike lanes. The linear model is slightly negative, suggesting that cities with rapidly growing bike commute rates seem to have faster rates of bike lane construction. However, a large number of outlying cities with rapid bike lane construction means that the regression model is a poor fit and it has a non-significant p-value of 0.64.

4.3.4.3 Perception of Safety

The perception of safety score as tabulated by PeopleForBikes from their City Rankings survey of cyclists across the country appears to have a modal distribution when compared with bike lane growth rates in

each city. Cities close to the median perception of safety score seem to be implementing their bike lane plans the fastest, while cities that are judged by their cyclists to be especially safe or especially dangerous are growing slower. The LOESS model seems to best fit this distribution. The linear regression model reports a non-significant finding with a p-value of 0.66.

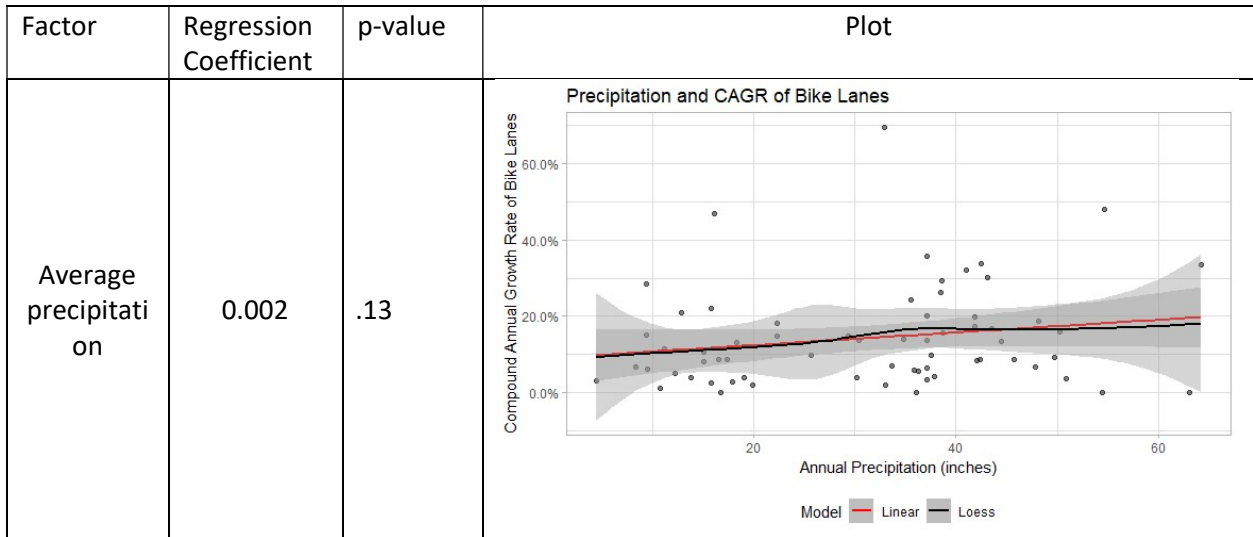
4.3.4.1 Bicycle Safety Points

The overall safety index score as calculated by PeopleForBikes appears to have a slight negative association with the annual growth of bike lanes in cities. In the index a higher score is equivalent to a safer city, so this means that growth of bike lanes may be slower in safer cities. Several cities with the lowest safety scores also have low growth in bike lanes, meaning that the LOESS models have a slightly modal shape. The linear regression model reports a non-significant finding with a p-value of 0.42.

4.3.5 Continuous climate factors

Only average precipitation showed any signs of significance. Results are shared in Figure 16 below.

Figure 16: Continuous climate factor



4.3.5.1 Average precipitation

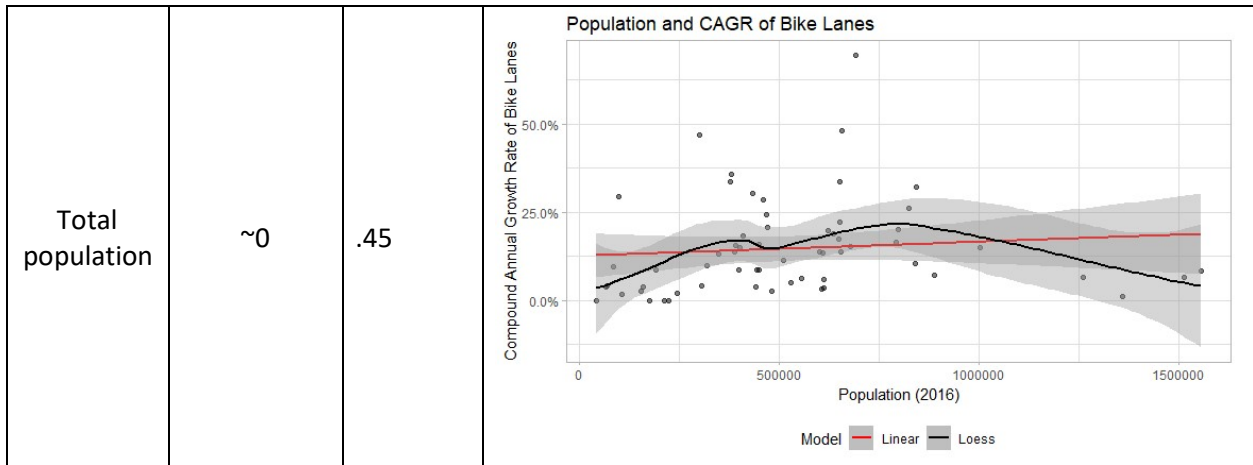
A visual inspection of the plot above shows a slight positive relationship between the average annual precipitation and the compound annual growth rate of bike lanes. The linear regression model reports a p-value of 0.13, not a statistically significant result at conventional levels.

4.3.6 City-specific factors

Three factors inherent to the built form or demographics of different cities showed signs of significance, shared below in Figure 17.

Figure 17: Continuous city-specific factors

Factor	Regression Coefficient	p-value	Plot
Health index	.0008	.047	
Median age	-0.01	.09	



4.3.6.1 Health index

The Wallethub health index score measures the quality of a city’s healthcare system as well as health outcomes, with a higher value representing a city with residents of lower health. A visual inspection of the plot shows a positive association, where cities with a relatively lower health ranking are implementing their bike lane networks faster.

Model diagnostics for the linear regression model indicate a significant result with a p-value of just below the threshold of 0.05.

4.3.6.2 Median age of residents

There appears to be a strong negative relationship between the median age of city residents and the rate at which a city builds out its bike lanes, where cities with an older populace build slower than cities with a younger populace. A few especially young and especially old cities may be responsible for this trend in the linear regression model. The LOESS model shows some local variation where cities with a median age in the early thirties are building relatively faster and cities with a median age in the mid-thirties are building relatively slower than the general linear trend.

The linear regression model reports a p-value of 0.09, a result that is not statistically significant.

4.3.6.3 Total population

The number of residents appears to have a slightly modal distribution when plotted against growth in bike lanes. Cities with about 700,000 residents seem to be building faster than both larger and smaller cities. The linear model attempts to draw a continuously positive trend, but the LOESS model tracks closer to the scatterplot. The p-value of 0.45 for the linear regression model shows a non-significant result. A GAM reports being able to explain 15.1% of the overall deviance between a city's raw population and the rate at which its government is building bike lanes. Both models appear to be influenced by the slow rates of bike lane growth in America's largest cities, and removing these from consideration may result in a relationship that is closer to the linear model. If this is done, the linear model becomes statistically significant with a p value of 0.008.

5 Discussion

This study investigated whether a variety of political, economic, social, and environmental factors were associated with measurable differences in the rate of bike lane construction, operationalized at the city level as compound annual growth rates. The results above provide evidence that differences in the rates at which cities are building bike lanes can be measured, compared, and analyzed at the level of the individual city. However, the results show very little pattern between the measured factors and the rate of bike plan build out. Although there are clear differences in the rate of bike plan implementation from city to city, all but a few of the factors examined in this study had no statistically significant and convincing relationship with these differences.

5.1 Non-significance

Most of the factors studied in this thesis were found to have little to no significant relationship with the rate at which cities are implementing their bike networks. While this finding may be disappointing to a researcher trying to find the most important factors, it could be liberating to practitioners and advocates facing constraints as they work to improve the transportation systems in their communities. Many of the attributes inherent to various cities found to have no statistical relationship with bike lane implementation are often believed to be barriers to a successful bike lane plan. If the number of very cold or hot days has no significant association on the rates of bike lane construction, then climate cannot be a reasonable excuse for slow progress on implementing a bike plan. If population growth has no significant association on CAGR of bike lanes, then cities can feel comfortable building out their networks regardless of whether their populations are growing or shrinking.

These non-significant results are similar to what was found by Herrman and Lewis (2018) in their paper on determinates of ballot measure success. Although the sample size in this thesis was larger, the lack of significant results was similar. The 65 cities included in this study exceeds the general rule of thumb of

40 observations minimum needed for meaningful statistical analyses, but the small dataset remains challenging for detecting meaningful associations using methods such as regression. Expanding the cities that were analyzed in this project to a larger sample size of cities may have helped find significant relationships, but it already included the largest American cities and a selection of mid-sized cities. Introducing smaller cities and towns would increase the sample size but might also mean that the cities included are less comparable to each other. The CAGR methods used in this thesis are an attempt to make Nashville and New York comparable, but extending that to smaller cities like Norwalk, CT would be challenging. Kerr et al. (2013) compared bicycle and pedestrian plans from all North Carolina municipalities against crash rates regardless of the number of residents, but the context of a statewide study makes that approach appropriate.

The overwhelmingly non-significant results of this thesis combined with the CAGR findings could signify that transportation agencies in the United States are able to overcome the factors that were hypothesized to be detrimental to plan implementation. Returning to the foundational books by Pressman and Wildavsky (1973) and Bardach (1977), plan implementation slows or fails when the implementation regime becomes too complex or fails to serve the competing interest of different agencies or parties. The fact that nearly all of the cities included in this thesis are seeing an expansion in their bike lane network may indicate that they have been able to overcome these implementation barriers. While some cities are seeing only slow growth below 5%, it is difficult to tell at a national level how much of a given city's slow implementation is the result of institutional barriers and how much is due to cities having already finished the "easy" projects. The ongoing work by NACTO (2018) with cities that have asked for help accelerating the build out of their bike plans has focused on some of the institutional issues reported in the foundational plan implementation literature in addition to technical issues of design.

Ultimately it appears that other factors are at play as the main influencers for the rate at which bike lanes are being built in American cities, either ones that are unmeasurable through quantitative methods or ones that were overlooked or excluded for feasibility reasons in the variable selection process. Some of the limitations of this thesis' approach are discussed further in the Conclusion section below along with opportunities for further research. As an exploratory data analysis, this thesis could be followed with a number of different efforts that could be used to address the limitations of this study, use alternative methods to examine the speed of implementation of citywide bike plans, or study similar topics.

6 Conclusions

The work presented in this thesis shows that few factors were significantly associated with the implementation of bike lanes in American cities. Some differences do exist in many of the factors that point to the existence of a sharp drop off in implementation rates once a city has completed its “low-hanging fruit” of easy projects. The significant factor that measures the size of each city’s bike lane network at the beginning of each study period shows this clearly. Many of the other factors show a relationship where better cycling conditions – as measured by Bike Score® or the percentage of bike commuters who are women or better cycling quality – are associated with slower implementation. This section reports the results of this thesis for each of the factors, discusses some of the limitations of the approach used in the thesis, and suggests opportunities for further research covering this and similar topics.

6.1 Summary of results

As demonstrated in the CAGR calculations, American cities are achieving a mean compound annual growth rate of 14% and a median annual growth rate of 10%. Only four of the sixty-five cities included in this thesis reported no growth, and no cities reported removing more bike lanes than they installed over the study period. The following tables and discussion restate the results presented in further detail above in the Results section for the various factor types.

6.1.1 Political factors results

Table 11 below summarizes results for the different political factors:

Table 11: Political factor results

Political Factor	Hypothesis	Observed Relationship	Significance
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Count of bicycle and pedestrian advocacy Groups	More groups accelerates plan implementation	Little to no difference in CAGR	No significance
Bicycle and pedestrian advocacy groups (residents per group)	More groups accelerates plan implementation	Little to no difference in CAGR	No significance
Presence of a bicycle advisory board or committee	No significant effect	Inconclusive, as only 3 cities have no advisory body	No significance
Successful passage of a Complete Streets ordinance or executive order	Accelerates plan implementation	Little to no difference in CAGR	No significance
Year of passage of a Complete Streets ordinance or executive order	Older policies accelerate plan implementation	Cities that adopted Complete Streets between 2011 and 2013 are implementing faster than cities with newer and older policies	No significance
NACTO membership	No significant effect	NACTO Membership associated with slightly higher CAGR	No significance
Number of mayors during study period	More mayoral turnover slows plan implementation	More mayoral turnover associated with lower CAGR	No significance

Although the tests described in the Results section show relationships like membership in NACTO was associated with faster CAGR and cities with more mayoral turnover tended to have lower CAGR, none of these relationships were found to be significant. Feasibility issues mean that politics factors that could be hypothesized to have significant relationships such as public support and turnover in city councils were excluded from this analysis.

6.1.2 Economic factor results

Table 12 below summarizes results for the economic political factors:

Table 12: Economic factor results

Economic Factor	Hypothesis	Observed Relationship	Significance
Bicycle and pedestrian investment amount	More funding accelerates plan implementation	Higher funding total associated with lower CAGR	No significance
Bicycle and pedestrian investment per capita	More funding accelerates plan implementation	Higher per capita associated with lower CAGR	No significance
Presence of a bicycle and pedestrian investment target or mandate	No significant effect	Slightly higher CAGR in cities with an investment target	No significance
Percent of residents below poverty line	Higher poverty levels slows plan implementation	Little to no difference in CAGR	No significance
Gini Index	Higher inequality slows implementation	Higher inequality associated with higher CAGR	No significance
City government financial index	A more fiscally stable government implements faster	Little to no difference in CAGR	No significance
City economic index	A wealthier populace accelerates plan implementation	Little to no difference in CAGR	No significance

None of the economic factors were found to have statistically significant relationships with CAGR. The presence of a target for annual investment levels, and higher inequality exhibited positive association with CAGR, but neither of these relationships were found to be statistically significant. Surprisingly, more funding seems to be associated with lower CAGR, although this was not a statistically significant result. One possible reason for the finding of no association is the fact that only one year of funding data was available. Another possibility is that the cost to build miles of bike lanes is the more important determinant rather than raw funding amounts. This unit-cost data is lacking at a national level across cities, potentially due to the fact that transportation projects of any kind vary wildly in their per-mile

costs based on many factors inherent not just to the individual city, but often down to the individual project or even block of street.

6.1.3 Implementation factor results

Table 13 below summarizes results for the bicycle plan implementation factors:

Table 13: Implementation factor results

Implementation Factor	Hypothesis	Observed Relationship	Significance
Initial size of bike network	Cities with a smaller initial network implement faster	Cities with a smaller initial network associated with higher CAGR	Significant
Bicycle and pedestrian staff per 100k residents	More staff leads to faster implementation	More staff per capita associated with lower CAGR	No significance
City infrastructure ranking	Cities with a higher infrastructure score implement faster	Little to no difference in CAGR	Significant

The size of the city’s bike network in the initial year used in the CAGR calculation has the strongest association of any of the factors studied. In other words, the cities that began with a smaller bike lane network built faster than cities that already had a large network. This follows intuitively, as the cities that already had a bike lane network at the beginning of the study period have likely already accomplished their “low-hanging fruit” projects. Projects that can be completed rapidly or at relatively low cost include road diets that build bike lanes on little-used and overly wide roads, or popular projects that improve cycling conditions along the highest demand corridors. Cities that have already accomplished these projects are now more likely to be working on routes that are technically or politically more challenging. The Wallethub infrastructure ranking is also significant, but the coefficient is very small. Decomposing this index score into its components may help shed light on what individual

factors within the index score representing the quality of a city’s infrastructure matter would be a good next step. Surprisingly, the per-capita count of staff working on bicycle and pedestrian issues had apparent negative associations with CAGR, although this was found to be non-significant.

6.1.4 Transportation factor results

Table 14 below summarizes results for the non-bicycle transportation factors:

Table 14: Transportation factor results

Transportation Factor	Hypothesis	Observed Relationship	Significance
Walk Score®	No significant effect	Little to no difference in CAGR	No significance
Transit Score®	No significant effect	Little to no difference in CAGR	No significance
Percent of households with no vehicles	Cities with more people without cars are faster to implement their bike plans	Cities with more people without cars associated with slower CAGR	No significance

The percent of households without access to a vehicle appears to be negatively associated with CAGR – cities whose residents have more access to private vehicles have higher CAGR. However, this relationship is not statistically significant, nor are the citywide Walk Score® and Transit Score® factors.

6.1.5 Bicycle factor results

Table 15 below summarizes results for the bicycle factors. Although some associations were evident, none of the bicycle factors were found to have a significant relationship with CAGR.

Table 15: Bicycle factor results

Implementation Factor	Hypothesis	Observed Relationship	Significance
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Bike Score®	Cities with already high Bike Scores® implement their plans slower	Cities with already high Bike Scores® are associated with lower CAGR	No significance
Change in bike commuter rate	Growing levels of bike commuting leads to faster implementation	Little to no difference in CAGR	No significance
Percent of bike commuters who identify as female	Higher share of women who commute by bike leads to faster implementation	Higher share of women who commute bike by associated with lower CAGR	No significance
Safety score	Worse safety rankings are associated with slower implementation	Worse safety rankings are associated higher CAGR	No significance
Perceived bike safety	Worse safety perceptions are associated with slower implementation	Cities with safety scores closer to the median have higher CAGR	No significance
Perceived quality of recreational cycling	Better recreational riding is associated with faster implementation	Better recreational riding is associated with lower CAGR	No significance
Presence of a bikeshare system	Cities with bikeshare build faster than cities without	Little to no difference in CAGR	No significance
Type of bikeshare system	Cities with fixed bikeshare build faster than cities with dockless or no bikeshare	Little to no difference in CAGR	No significance

A higher Bike Score®, a higher share of bike commuters who identify as female, and a higher perceived quality of recreational cycling amenities with a community all have negative associations with CAGR.

These three factors are three different ways of measuring the quality of cycling within a city and all seem to suggest that cities that are already better for cycling are implementing slower. Cities with a lower safety score as calculated by PeopleForBikes as part of their City Rankings project tended to have faster bike lane implementation. However, one component of PeopleForBikes' safety score, self-reported perceived safety, had a different relationship with CAGR than did the overall safety score. Cities closer to

the median on perceived safety tended to implement faster than cities that are perceived by resident cyclists to be especially safe or especially unsafe. There is no evidence that growing or shrinking bike commuter rates in general is associated with bike lane implementation speed. There is also no link between either the presence or type of bikeshare systems, perhaps due to the fact that bikeshare is now nearly ubiquitous in American cities.

6.1.6 Weather and climate factor results

Table 16 below summarizes results for the weather and climate factors:

Table 16: Weather and climate factors

Data Type	Hypothesis	Observed Relationship	Significance
Average number of days with minimum temperature below freezing	Cities with more cold days are slower to implement their plans	Little to no difference in CAGR	No significance
Average number of days with maximum temperature below freezing	Cities with more very cold days are slower to implement their plans	Cities with more very cold days have a higher CAGR	No significance
Average number of days with maximum temperature above 90° F	Cities with more hot days are slower to implement their plans	Little to no difference in CAGR	No significance
Average annual precipitation (inches)	Cities with more precipitation are slower to implement their plans	Cities with more precipitation have a higher CAGR	No significance

The number of very hot days and the number of days with a minimum temperature that dipped below freezing had no clear relationship with CAGR, but the number of days where the maximum temperature never rose above freezing and the amount of days with rain actually seem to have positive relationships with CAGR. None of these weather factors have a statistically significant relationship with CAGR,

indicating that municipal transportation agencies and their contractors have been able to overcome whatever climate-related disadvantages they face.

6.1.7 City-Specific factors results

Table 17 below summarizes results for the factors inherent to each city and its people:

Table 17: City-specific factor results

Data Type	Hypothesis	Observed Relationship	Significance
Area (square miles)	No significant effect	Larger cities have a higher CAGR	No significance
Total population	No significant effect	Cities with more residents have a higher CAGR	No significance
Density (people per square mile)	Denser cities are slower to implement their plans	Little to no difference in CAGR	No significance
Population growth	Growing cities are slower to implement their plans	Little to no difference in CAGR	No significance
Presence of a legacy transit system or pre-auto urban form	Cities with more constrained right of way are slower to implement their plans	Little to no difference in CAGR	No significance
Median age	Cities with a younger populace are faster to implement their plans	Cities with a younger populace have a higher CAGR	No significance
Percent non-white and/or Hispanic	No significant effect	Little to no difference in CAGR	No significance
City's region within the United States	Northeastern and Southern cities implement slower than Midwestern and Western cities	Northeastern and Western cities have a lower CAGR than Southern and Midwestern cities	No significance
Education index	Cities with a more educated populace implement faster	Cities with a more educated populace have a lower CAGR	No significance
Health index	Cities with a healthier populace implement faster	Cities with a healthier populace have a lower CAGR	Significant

Public safety index	No significant effect	Cities with a lower safety index rank have a higher CAGR	No significance
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The number of people living within a city has a positive association with CAGR, where larger cities are implementing their bike lane plans faster, although this is only significant in cities with less than one million residents. The Wallethub health index significantly showed that cities with a less healthy populace and a weaker health system in general are implementing their bike lane networks faster. However, the relationship appears to be weak given the small coefficient.

Cities with a larger area, a younger populace, and a lower Wallethub public safety score are all associated with higher CAGR, but these relationships are not statistically significant. Education appears to have a negative relationship, with cities that ranking better on the Wallethub education index having a lower CAGR than cities that rank worse. There appear to be regional differences where Northeastern and Western cities are building out their bike lane networks at about half of the rate of Southern and Midwestern cities, although none of these relationships are statistically significant. Finally, density, population growth, and the presence of a legacy transit system or dominant pre-auto urban form all appear to no clear relationships with bike lane network expansion.

6.2 Limitations

Several limitations of this project could be addressed in future research that may be better able to detect the factors behind high and low performing bicycle plan implementation.

6.2.1 Timespan

First, reducing the implementation of bike lanes that may have been developed over the time period of a decade or more to a single number may obscure meaningful variations that occurred within that

period. An example is Indianapolis, which took advantage of a federal TIGER grant and other funding to build a network of high-quality protected bike lanes in downtown and nearby neighborhoods (Sinpatanasakul 2017). Along with other projects in the city, this helped grow the bike lane network from four to fifty-nine miles in just two years between 2007 and 2009. However, the calculations used in this thesis reduces that achievement to a compound annual growth rate of 32% because Indianapolis made slower progress after 2009. An approach that accounts for year-to-year variation in implementation would be able to detect this rapid expansion.

Second, the various factors that this thesis studied are taken from points in time or ranges of time that do not necessarily match up with the start and end dates used for each city's CAGR calculation. For example, population is from the 2016 American Community Survey, the perception of bicycling safety is from a 2018 PeopleForBikes survey, and funding levels are from the 2014 Alliance for Walking and Biking survey results. Some factors cover time ranges, such as change in city population and bike commuter rates, both of which represented the period 2010-2016. This discrepancy between the times covered by CAGR and the times covered by the forty-three factors could be responsible for the lack of statistical significance, as the relationships that are theorized to exist may be obscured by mismatches in time spans. A regression approach where the slope of bike lane implementation is calculated from year to year would account for this, but limitations in the Alliance for Walking and Biking survey data precluded this approach.

6.2.2 Omitted Variables

Many different factors that could be hypothesized to affect the compound annual growth of bike lanes are omitted due to data collection and time issues. Perhaps the most important is the level of public support for transportation plans. Some cities commission opinion polls as they draft plans, while in other cities the news media or universities conduct similar assessments as part of their coverage or studies

(Schmitt 2013). But this is an ad-hoc process and no easily accessible national compilation of survey results by city exists. Public opposition to individual bike lane projects is a well-documented phenomenon in the news media known as “bikelash”, but it is difficult to quantify beyond these opinion polls and its effects on a broad scale are unknown. Funding is intuitively an extremely important driver of bike lane construction rates, but was found to be non-significant in this thesis. The fact that the limited funding data that was available was found to be non-significant was surprising, and probably linked to the many cities that did not provide an answer to the survey question in the original data. Perhaps cost is the more important driver rather than funding amounts – bike lane construction costs vary wildly from a few thousand dollars to millions of dollars per mile depending on the type of project and so different cities building different infrastructure types can end up with very different network sizes given the same amount of funding.

6.3 Avenues for further quantitative research

The remainder of this thesis discusses opportunities for further work on this topic as well as similar topics.

6.3.1 Alternative Metrics and Evaluating Other Infrastructure Types

Several metrics other than the compound annual growth rate could be used to track the implementation of bike lanes. An annual average percent change calculation could be used with the Alliance for Walking and Biking survey data instead of compound annual growth rates. However, as stated above this approach can overstate sustained growth if there are a few years of rapid growth followed by a plateau, or if a city is starting from scratch. The annual average percent change formula applied to the Alliance for Walking and Biking survey data results in several cities having “annual” growth rates in excess of 100% and even 200%, which vastly overstates the ability of cities to sustainably implement their plans from year to year. Finally, regression methods could be used to calculate a slope based on the annual

growth rate from year to year. However, issues with the Alliance for Walking and Biking data as discussed above make it challenging to verify each year's survey response for each city, as so due to time constraints this approach was discarded in favor of verifying only mileage totals for a start and end year.

Alternative data sources for measuring the rate at which cities build out their bike networks may address some data inconsistencies. The first potential data source is officially reported bike lane network mileage figures from city transportation planning documents collected from several points in time. This would allow the researcher to see whether buildout was recorded as lane-mile or centerline totals and with details on exactly which infrastructure types are included in the total. Some issues would still remain, such as if cities report using centerline totals in their first bicycle network plan and lane-mile totals during their next update, although correction factors could be applied to standardize the data. Regardless, going directly to the source would likely result in higher quality data and a better understanding of how each city arrived at their totals.

The second source would be to use another dataset, the PeopleForBikes Protected Bike Lanes tracking spreadsheet. As discussed in the literature review, this spreadsheet is maintained by PeopleForBikes staff and tracks individual protected bike lanes from planning through to construction. The data is high quality and could allow for much more detailed analysis, but overall national mileage built is relatively low for such a narrowly selected infrastructure type. This makes it difficult to perform a longitudinal analysis with such small totals overall, but with a few more years of data will likely become a valuable dataset for this type of research.

A final alternative source on tracking the expansion of bike infrastructure networks would be to use a geographic information system (GIS) approach that uses open source data such as OpenStreetMaps. OpenStreetMaps contributors track new or upgraded bike lanes as one of many attributes of a street, and the website maintains a history function that tracks all the changes made to each street. This could

be used to develop a longitudinal dataset tracking the expansion of bike lanes across the United States or even the world – the history for each street could be saved and processed programmatically, then compiled to citywide totals by year. This approach could automate the process of measuring bike lane expansion, but is dependent on OpenStreetMaps data accurately representing the installation of new bike lanes in a timely and spatially unbiased and complete manner. This is the approach used in the PeopleForBikes City Rankings project, which surmounts data issues from OpenStreetMaps by accepting GIS data submissions from city staff to supplement what they download from OpenStreetMaps. In time this project will likely yield a high quality, nationally comparable dataset, and PeopleForBikes is already using the first two years of data to develop an acceleration score to quantify the rate at which bike lanes are being constructed in each city.

6.4 Avenues for further qualitative research

The quantitative methods selected by this thesis appear to show that the implementation of bike lanes may be a highly individualized process determined by attributes internal to each city or even each project. While some of the difficulties of quantitative work on topics such as public support are discussed above, qualitative methods may yield insights that practitioners can take back to their own work. This approach has been generalized by Bardach (1977) amongst others discussed in the literature review, and is now being pursued in highly specific projects such as NACTO's Green Light for Great Streets project. This uses interviews and small surveys to shed light on some of the topics that could not be addressed in this thesis. While this thesis was able to examine the effects of annual funding amounts, NACTO was able to find the nuances associated with transportation funding and discuss the importance of finding predictable funding streams rather than raw dollars. NACTO ultimately recommended, as the result of dozens of interviews, that city staff seek "recurring or guaranteed funding sources so that staff spend less time chasing grants, and more time actually implementing" (NACTO 2018). This thesis was not able to measure internal workflows beyond the number of staff working on bicycle and pedestrian

issues, but NACTO's qualitative work was able to develop recommendations on the topics as fine as the use of consultants versus internal staff and the importance of standardizing designs to speed up project delivery.

Case studies are another useful methodology for qualitative research into transportation project delivery. The second phase of NACTO's Green Light for Great Streets project included extensive case studies and staff assistance which they used to test the hypotheses developed during their earlier research. This included staff support for bike lane implementation in San Jose and Pittsburgh, the lessons from which could be applied to other cities. The work of researchers such as Van Oort et al. (2015), who studied successful and failed light rail projects in the Netherlands and France, cover each case in less depth than NACTO but were able to find five diverse projects to profile.

6.5 Additional infrastructure worthy of further study

An evolution of this project could look at other bicycle infrastructure types in addition to on-street bike lanes, such as bike paths or bicycle boulevards. Future research could separate out the different types of infrastructure and track the implementation of each type to search for patterns in how city staff preferentially implement one type or another based on their city's unique attributes, needs, and resources.

A similar approach to the one used in this study could investigate transit projects in addition to bike lanes. Fixed-guideway transit such as light rail, subways, and bus rapid transit are expensive and slow to expand, meaning that each individual project must survive years of economic, political, and demographic change within a city that can obscure factors that lead to fast or slow implementation. The one type of transit infrastructure seeing rapid expansion similar to bike lanes is on-street bus lanes, which are currently undergoing a renaissance in the United States. Fast, inexpensive, and popular with bus riders, these are similar in many ways to the bike lanes studied in this thesis (Gahbauer and Matute

2019). But the new boom in bus lane implementation is even more recent than that of protected bike lanes and is not yet tracked and studied to the extent that bike lanes have been. This is certain to change with time the same way that advocacy and professional organizations began to seriously study bike lane implementation in the 2010s, and indeed projects are already in the works. The online report *Best Practices in Implementing Tactical Transit Lanes* by researchers at UCLA appears to be the first with a publication date of March, 2019 (Gahbauer and Matute 2019).

This project focused only on the construction of bicycle lanes and will leave the build-out of bus lanes, light rail lines, and other transit infrastructure to another future project. This project also did not analyze pedestrian master plans or similar citywide pedestrian planning documents, since these typically lack a strong spatial element. Very few American cities are still building a highway and road network intended for general use, so this project will not be including these plans, if they even exist. Highway construction continues, but tends to be individual capacity expansions, safety upgrades, or construction to serve or incent growth in new areas of a city.

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8 Appendix A: List of cities

8.1 Cities

The following cities are included in the full Alliance for Walking and Biking survey that makes up the main data source for this thesis. Jacksonville, Miami, and San Antonio were removed from the CAGR calculation as their reported mileage figures could not be verified online.

Albuquerque, Arlington, TX, Atlanta, Austin, Baltimore, Boston, Charlotte, Chicago, Cleveland, Colorado Springs, Columbus, Dallas, Denver, Detroit, El Paso, Fort Worth, Fresno, Houston, Indianapolis, *Jacksonville*, Kansas City, MO, Las Vegas, Long Beach, Los Angeles, Louisville, Memphis, Mesa, *Miami*, Milwaukee, Minneapolis, Nashville, New York, Oakland, Oklahoma City, Omaha, Philadelphia, Phoenix, Portland, OR, Raleigh, Sacramento, *San Antonio*, San Diego, San Francisco, San Jose, Seattle, Tucson, Tulsa, Virginia Beach, Washington, DC, Wichita

8.2 Smaller cities

The following mid-sized cities are included in the Alliance for Walking and Biking survey that makes up the main data source for this thesis. The Alliance for Walking and Biking began surveying these cities later than the ones in the list above, but the two lists are combined for the purposes of this thesis. Charlestown was removed from the CAGR calculation as its reported mileage figures could not be verified online.

Albany, Anchorage, Baton Rouge, Bellingham, Boulder, Burlington, *Charleston*, Chattanooga, Davis Eugene, Fort Collins, Honolulu, Madison, Missoula, New Orleans, Pittsburgh, Salt Lake City, Spokane, St Louis

9 Appendix B: 2018 Benchmarking Survey Instrument

» COMMUNITY SURVEY

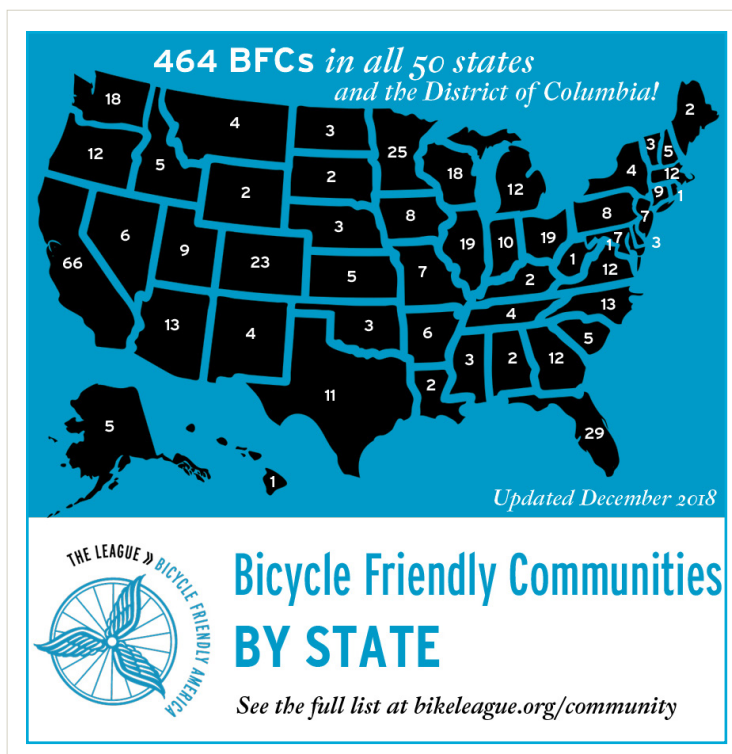
The community survey used for the 2018 Benchmarking Report is based on the application for a Bicycle Friendly Community (BFC) award. The BFC program was created in 1995 and significantly updated to its “5 E” (Engineering, Education, Encouragement, Enforcement, and Evaluation & Planning) format in 2002. It has been updated periodically since then in order to account for new actions taken by communities, such as bikeshare and an increased interest in separated or protected bike lanes. In 2014-2015 it was updated as part of the League of American Bicyclists’ Equity Initiative.

The Benchmarking Report began in 2007 under the Alliance for Biking and Walking. Its city survey was not coordinated with the BFC application. In order to provide comparable data, supplemental questions were added to the Fall 2017 BFC application round and can be found at the end of the survey. Each question added for specifically for the Benchmarking Report begins with the prefix BMR.

In several cases, there were questions in the existing BFC application that closely mirrored but did not precisely follow past Benchmarking Report questions. Existing questions that were modified after comparison to past Benchmarking Report questions are highlighted in **GREEN**.

The community survey was distributed to all contacts that had submitted past Benchmarking Report surveys to the Alliance and the most recent contacts who had submitted BFC applications for the 67 of 69 communities included in past Benchmarking Reports that had participated in the BFC program. Distribution occurred through several rounds of email and phone calls in some cases, including to new contacts identified from community websites.

You can learn more about the BFC program at <https://bikeleague.org/community>.



Engineering

» POLICIES AND DESIGN STANDARDS

B1. Does your community currently have any of the following policies in place?

- Local Complete Streets ordinance adopted by local governing body*
- Local Complete Streets policy*
- Local bicycle routine accommodation policy*
- Local Complete Streets or bicycle routine accommodation resolution*
- None of the above

***B1A.** What year was the ordinance, policy, or resolution adopted or passed?

***B1B.** Please provide a link to the ordinance, policy, or resolution.

***B1C.** Since the adoption of the ordinance, policy, or resolution, what percentage of the implemented road projects (where bicycle facilities were considered) have included bicycle facilities?

- 0-10%
- 11-25%
- 26-50%
- 51-75%
- More than 75%
- Unknown

B2. Does your community have bicycle facility selection criteria that increases separation and protection of bicyclists based of levels of motor vehicle speed and volume?

- Yes*
- No

***B2A.** Please describe.

B3. Does your community currently have any of the following policies in place that promote shorter distances between homes and destinations? Check all that apply.

- Mixed-use zoning or incentives
- Planned Unit Development zoning
- Transit Oriented Development ordinance or program
- Form-based/design-based codes
- Connectivity policy or standards
- None of the above

B4. Does your community currently have any of the following street design policies in place that promote a more comfortable cycling environment? Check all that apply.

- Design manual that incorporates the AASHTO Guide for the Development of Bicycle Facilities, 4th Edition
- Design manual that incorporates the NACTO Urban Bikeway Design Guide
- Design manual that incorporates the NACTO Urban Street Design Guide
- Design manual that incorporates the FHWA's Small Town and Rural Multimodal Network Guide
- Streetscape design guidelines
- None of the above

B5. Does your community currently have any of the following additional policies in place? Check all that apply.

- Policy to preserve abandoned rail corridors for multi-use trails
- Policy to utilize utility corridors for multi-use trails
- Accommodation of bicyclists through construction sites in the public right-of-way
- Maximum car parking standards
- No minimum car parking standards
- Paid public car parking
- Shared-parking allowances
- Congestion charges
- None of the above

Existing questions that were modified after comparison to past Benchmarking Report questions are highlighted in GREEN.

B6. How do engineers and planners learn how to accommodate bicyclists according to the most current AASHTO or NACTO standards? Check all that apply.

- FHWA/National Highway Institute Training Course
- Portland State University Initiative for Bicycle and Pedestrian Innovation Training Course
- Staff participate in bicycle-specific conferences/trainings/educational tours
- Webinars
- Internal peer training
- Training by outside consultant/advocate
- Require project consultants to have bike/ped qualifications
- None of the above

» END-OF-TRIP FACILITIES

B7. What policies or programs increase the amount of end-of-trip facilities for bicyclists? Check all that apply.

- Bike parking ordinance for existing buildings specifying amount and location
- Bike parking ordinance for all new developments specifying amount and location
- Ordinance requiring showers and lockers in existing non-residential buildings
- Ordinance requiring showers and lockers in new non-residential buildings
- Building accessibility ordinance (Bicycles are allowed to be parked inside non-residential buildings)
- Public uncovered bike racks
- Public covered bike racks
- Bike valet parking available at community events
- Ordinance that allows on-street bike parking/bicycle corrals
- Ordinance that allows bike parking to substitute for car parking
- Requirement for new developments to meet LEED-Neighborhood Development silver standards or higher
- Developers are eligible for density bonuses for providing end-of-trip facilities
- Subsidy program for private bike parking installation
- Public or private program that provides grants for bike racks or free bike racks upon request
- None of the above

B8. What, if any, end-of-trip facilities are available to the general public in your community? Check all that apply.

- Publicly accessible bicycle repair stations
- Publicly accessible air pumps
- Bicycle Station or Hub that provides lockers and/or showers for commuters
- None of the above

B9. Do your standards for bicycle parking: Check all that apply.

- Conform with APBP Guidelines?
- Address the need for parking spaces for cargo bicycles?
- Address the need for facilities to recharge electric assist bicycles?
- No standards

B10. What percentage of public and private bike racks conform with APBP Guidelines?

- 10% or less
- 11-25%
- 26-50%
- 51-75%
- More than 75%
- Unknown

B11. Is there a program (e.g. publicly funded, public-private partnership, or development regulation) that provides or increases bike parking at any of the following locations?

Check all that apply.

- Public & private schools (K-12)
- Day care, child care centers and preschools
- Higher Education Institutions
- Libraries
- Hospitals and medical centers
- Parks & recreation centers
- Other government-owned buildings and facilities
- Event venues (e.g. convention center, movie complex)
- Hotels & restaurants
- Office buildings
- Retail stores (excluding grocery stores)
- Grocery stores
- Multi-family housing (excluding subsidized or public housing, if any)
- Subsidized or public housing
- None of the above

» BICYCLE ACCESS TO PUBLIC TRANSPORTATION

B12. Does your community have a rail transit or bus system?

- Yes*
- No

***B12A.** Are bikes allowed inside transit vehicles? Check all that apply.

- Yes, at all times in buses
- Yes, at all times in rail vehicles
- Only outside of rush hour service in buses
- Only outside of rush hour service in rail vehicles
- Folding bikes are allowed in folded position in buses
- Folding bikes are allowed in folded position in rail vehicles
- There is specialized space (e.g. hooks or luggage space) for bikes in buses
- There is specialized space (e.g. hooks or luggage space) for bikes in rail vehicles
- None of the above

***B12B.** What percentage of buses are equipped with bike racks?

- None
- 10% or less
- 11-25%
- 26-50%
- 51-75%
- 75-99%
- 100%

***B12C.** What percentage of transit stops are equipped with secure and convenient bike parking, including bus stops?

- None
- 10% or less
- 11-25%
- 26-50%
- 51-75%
- 75-99%
- 100%
- Unknown

***B12D.** Has your community made specific bicycle infrastructure investments around major transit stops to improve accessibility?

- Yes*
- No

*Please describe any bicycle infrastructure investments around major transit stops that have improved accessibility.

***B12E.** How are residents and visitors encouraged to combine cycling and public transportation? Check all that apply.

- Cyclists can practice mounting their bike on a bus bike rack at community events
- Brochure describing bike rack use/how to store bikes inside a transit vehicle
- Video describing bike rack use/how to store bikes inside a transit vehicle
- Information on bike racks/storage provided on transit schedules
- Stickers on the outside of buses with bike racks that say bicycles are welcome
- None of the above

» OFF-STREET BICYCLE FACILITIES

B13. Are there any off-street facilities within your community's boundaries that can be legally used by bicyclists?

- Yes*
- No

***B13A.** How many miles of the following off-street accommodations that can be legally used by bicyclists are within your community's boundaries? Answer all that apply. (in miles)

- Paved shared use paths (≥10 feet) (# only)
- Paved shared use paths (≥ 8 and <10 feet) (# only)
- Natural surface shared use paths (≥10 feet) (# only)
- Natural surface shared use paths (≥ 8 and <10 feet) (# only)
- Singletrack (# only)

Existing questions that were modified after comparison to past Benchmarking Report questions are highlighted in GREEN.

***B13B.** Which of the following features are provided for bicyclists and pedestrians at off-street path crossings of roads with posted speed limits above 25 mph? Check all that apply.

- Bike/pedestrian overpasses/underpasses
- Raised path crossings
- Refuge islands
- Path crossing with high visibility markings/signs/HAWK signals/ Rapid Flashing Beacons
- Curb extensions
- Signalized crossings
- None of the above
- N/A – no crossings of roads with posted speed limits above 25 mph

***B13C.** What measures have been taken to improve the safety and convenience of bicyclists on off-street paths? Check all that apply.

- “Cut-throughs” that improve network connectivity for bicyclists (e.g. connecting dead-ends or cul-de-sacs)
- Off-street way-finding signage with easily visible distance and/or riding time information for bicyclists while riding
- Parallel but separated paths for bicyclists and pedestrians
- Signage or markings to designate right-of-way on shared-use paths
- Education/awareness campaign about shared-use path etiquette
- None of the above

***B13D.** What maintenance practices ensure the off-street bicycle facilities remain usable and safe?

Sweeping

- Quarterly or more frequently
- Annually
- As needed
- Never

Vegetation maintenance

- Quarterly or more frequently
- Annually
- As needed
- Never

Snow and ice clearance

- N/A - No snow or ice
- Before roadways
- Same time as roadways
- After roadways
- Never

Surface repair

- Within 24 hours of complaint
- Within one week of complaint
- Within one month of complaint or longer
- Never

» ON-STREET BICYCLE FACILITIES

B14. What is the centerline mileage of your total road network (including federal, state, county and private roads)? (# only)

B15. How many miles of road network fall within the following posted speed limits? (in centerline miles)

- ≤ 25mph (# only)
- >25mph and ≤35mph (# only)
- >35mph (# only)

B16. Does your community have on-street bicycle facilities?

- Yes*
- No

***B16A.** Are there any on-street bicycle facilities on roads with posted speeds of ≤ 25mph?

- Yes**
- No

****B16A1.** On streets with posted speeds of ≤ 25 mph, how many miles of each of the following bicycle facilities are there that meet or exceed current AASHTO or NACTO standards? (Answer in centerline miles. Write “o” if facility is not present in community.)

- Bike boulevards (# only)
- Shared lane markings (not counted under Bicycle Boulevards) (# only)
- Wide paved shoulders (ridable surface ≥ 4 feet, and minimum clear path of ≥ 4 feet between rumble strips) (# only)
- Bike lanes (incl. standard, contra-flow, left-side) (ridable surface ≥ 4 feet) (# only)
- Buffered bike lanes (# only)
- Protected bike lanes (one-way or two-way) (# only)
- Raised cycle tracks (one-way or two-way) (# only)

***B16B.** Are there any on-street bicycle facilities on roads with posted speeds of >25 mph and ≤ 35 mph?

- Yes**
- No

****B16B1.** On streets with posted speeds of > 25 mph and ≤ 35 mph, how many miles of each of the following bicycle facilities are there that meet or exceed current AASHTO or NACTO standards? (Answer in centerline miles. Write “o” if facility is not present in community.)

- Shared lane markings (# only)
- Wide paved shoulders (ridable surface ≥ 4 feet, and minimum clear path of ≥ 4 feet between rumble strips) (# only)
- Bike lanes (incl. standard, contra-flow, left-side) (ridable surface ≥ 4 feet) (# only)
- Buffered bike lanes (# only)
- Protected bike lanes (one-way or two-way) (# only)
- Raised cycle tracks (one-way or two-way) (# only)

***B16C.** Are there any on-street bicycle facilities on roads with posted speeds of >35 mph?

- Yes**
- No

****B16C1.** On streets with posted speeds of > 35 mph, how many miles of each of the following bicycle facilities are there that meet or exceed current AASHTO or NACTO standards? (Answer in centerline miles. Write “o” if facility is not present in community.)

- Wide paved shoulders (ridable surface ≥ 4 feet, and minimum clear path of ≥ 4 feet between rumble strips) (# only)
- Bike lanes (incl. standard, contra-flow, left-side) (ridable surface ≥ 4 feet) (# only)
- Buffered bike lanes (# only)
- Protected bike lanes (one-way or two-way) (# only)
- Raised cycle tracks (one-way or two-way) (# only)

***B16D.** What maintenance practices ensure that any on-street bicycle facilities (including shoulders) remain usable and safe?

Sweeping

- Before other travel lanes
- Same time as other travel lanes
- After other travel lanes
- Never

Snow and ice clearance

- N/A - No snow or ice
- Before other travel lanes
- Same time as other travel lanes
- After other travel lanes
- Never

Pothole maintenance/ surface repair

- Within 24 hours of complaint
- Within one week of complaint
- Within one month of complaint or longer
- Never

B17. Within the last five years, has your community ever removed a bicycle facility without an improved replacement?

- Yes*
- No

*If yes, please explain.

» OTHER BICYCLE ACCOMMODATIONS

B18. How has your community calmed traffic? Check all that apply.

- Speed limits 20 mph or less on residential streets
- Used lower design speeds when designing for new roadways
- Physically altered the road layout or appearance
- Converted one-way streets to two-way traffic
- Road diets
- Lane diets
- Speed feedback signs/cameras
- Car-free/Car-restricted zones
- Shared Space/Home Zone/Living Street/Woonerf
- None of the above

B19. In what other ways has your community improved riding conditions and amenities for on-street bicyclists?

Check all that apply.

- Roundabouts that accommodate bicycles
- Colored bike lanes outside of conflict zones
- Contra-flow bike lanes (e.g. a one-way bike lane installed heading the opposite direction of the adjacent one-way street)**
- Removal of on-street car parking
- Advisory bike lanes
- Bicycle left turn lanes
- Shared bicycle/bus lanes
- Reverse angle parking
- On-street way-finding signage with distance and/or time information
- Signed bike routes
- Bicycle-friendly storm sewer grates
- None of the above

B20. Are there any signalized intersections in your community?

- Yes*
- No

***B20A.** Which of the following accommodations are available at signalized intersections to improve conditions for bicyclists?

- Video or microwave detection for demand-activated signals
- Demand activated signals with loop detector (and marking)
- Push-buttons that are accessible from the road
- Timed signals
- Signals timed for bicycle speeds
- Bicycle Signal Heads
- Advanced Stop Line or Bike Box
- Protected intersection
- Colored bike lanes in conflict areas
- Intersection crossing markings for bicycles
- Refuge islands
- Right corner islands (“pork chops”)
- None of the above

» BIKE SHARING

B21. Does your community currently have a community-wide bike sharing program that is open to the general public?

- Yes*
- No
- Launching in the next 12 months**

*If yes:

***B21A.** Please provide a link to your bike sharing program website.

***B21B.** What is the name of your city’s bike share program?

***B21C.** Who is involved in implementation of this program? Implementation includes operation and financial support.

- Government
- Nonprofit organization

Existing questions that were modified after comparison to past Benchmarking Report questions are highlighted in GREEN.

***B21D.** What type of system is your bike sharing program?

- Automated kiosk-style bike share system
- GPS-enabled bike share system
- Short-term bike rentals
- Long-term bike rentals
- Bike library (free rentals)
- Unregulated program (i.e. Yellow Bike)

***B21E.** How many bikes are in the system? (# only)

***B21F.** How many stations are in the system?

***B21G.** What is the average station density? (number of stations per square mile)

***B21H.** How many trips were made in the last calendar year?

***B21I.** Are there options for transporting children as passengers?

- Yes
- No

***B21J.** What specific efforts, if any, have been implemented to make the bike sharing program accessible to low-income populations your community? Check all that apply.

- Cash or non-credit card dependent payment system
- Subsidized bike share memberships
- Community outreach
- Walkable station spacing in low-income communities
- None of the above

***B21K.** Does your bike share program make ridership publicly available online?

- Yes
- No
- N/A – no ridership data collected

****If launching in next 12 months:**

Existing questions that were modified after comparison to past Benchmarking Report questions are highlighted in GREEN.

****B21L.** Expected launch date:

****B21M.** Please provide a link to your bike sharing program website.

****B21N.** What is the name of your city's bike share program?

****B21O.** Who is involved in implementation of this program? Implementation includes operation and financial support.

- Government
- Nonprofit organization

****B21P.** What type of system will your bike sharing program be?

- Automated kiosk-style bike share system
- GPS-enabled bike share system
- Short-term bike rentals
- Long-term bike rentals
- Bike library (free rentals)
- Unregulated program (i.e. Yellow Bike)

****B21Q.** How many bikes will be in the system? (# only)

****B21R.** How many stations will be in the system?

****B21S.** Will there be options for transporting children as passengers?

- Yes
- No

***B21T.** What specific efforts, if any, are being planned to make the bike sharing program accessible to low-income populations your community? Check all that apply.

- Cash or non-credit card dependent payment system
- Subsidized bike share memberships
- Community outreach
- Walkable station spacing in low-income communities
- None of the above

» OTHER BICYCLE-RELATED AMENITIES

B22. Which of the following bicycling amenities are available within your community boundaries? Check all that apply

- BMX track
- Velodrome
- Indoor cyclist training facility
- Cyclocross course
- Mountain bike park
- Pump tracks
- Bicycle-accessible skate park
- Snow/Fat tire bike trails
- Signed loop route(s) around the community
- None of the above

B23. Which of the following safety amenities are available in your community? Check all that apply

- Emergency call boxes/phones along trails
- Street lighting on most arterials
- Street lighting on most non-arterials
- Lighting of most shared-use paths
- None of the above

» ENGINEERING BONUS POINTS

B24. Describe any other policies, amenities, infrastructure improvements or maintenance programs that your community provides or requires that create a comfortable and attractive bicycling environment for bicyclists of all ages and abilities. Use this space to expand on answers checked above, or to describe additional facilities or physical amenities provided that have not yet been covered.

Education

» YOUTH BICYCLE EDUCATION

C1. Do any public or private elementary schools offer regular bicycle education to students?

- Yes*
- No
- N/A - No elementary schools

***C1A.** What percentage of your public and private elementary schools offer bicycle education?

- 1-25%
- 26-50%
- 51-75%
- 75-99%
- 100%

***C1B.** What type of bicycle education is offered?

- Mandatory on-bike education
- Optional on-bike education
- Bicycle safety presentation with no on-bike component

***C1C.** Are bicycles provided to students by the school district, police, nonprofit or other entity to allow every student the opportunity to participate in on-bike instruction?

- Yes, bicycles are provided to all students
- Yes, a limited number of bicycles are available for students in need
- No, bicycles are not provided

C2. Do any public or private middle schools offer regular bicycle education to students?

- Yes*
- No
- N/A - No middle schools

***C2A.** What percentage of your public and private middle schools offer regular bicycle education?

- 1-25%
- 26-50%
- 51-75%
- 75-99%
- 100%

***C2B.** What type of bicycle education is offered?

- Mandatory on-bike education
- Optional on-bike education
- Bicycle safety presentation with no on-bike component

***C2C.** Are bicycles provided to students by the school district, police, nonprofit or other entity to allow every student the opportunity to participate in on-bike instruction?

- Yes, bicycles are provided to all students
- Yes, a limited number of bicycles are available for students in need
- No, bicycles are not provided

C3. Do any public or private high schools offer regular bicycle education to students?

- Yes*
- No
- N/A - No high schools

***C3A.** What percentage of your public and private high schools offer regular bicycle education?

- 1-25%
- 26-50%
- 51-75%
- 75-99%
- 100%

***C3B.** What type of bicycle education is offered?

- Mandatory on-bike education
- Optional on-bike education
- Bicycle safety presentation with no on-bike component

***C3C.** Are bicycles provided to students by the school district, police, nonprofit or other entity to allow every student the opportunity to participate in on-bike instruction?

- Yes, bicycles are provided to all students
- Yes, a limited number of bicycles are available for students in need
- No, bicycles are not provided

C4. Outside of schools, how are children and youth taught safe cycling skills?

Check all that apply.

- Learn to ride classes
- Bike clinics or rodeos
- ABCs of Family Biking, family bike show-and-tell, or similar program focused on families with toddlers and young children
- Youth bike clubs
- Scouts bicycle training
- Youth development road or cross racing teams
- Youth development mountain bike racing teams
- Helmet fit seminars
- Safety town area
- Trail riding classes
- Summer camps
- Bicycle-related after school programming
- Bicycle safety is taught as part of driver education curriculum
- None of the above

» ADULT BICYCLE EDUCATION

C5. Are bicycle safety or riding skills-related classes or hands-on instruction offered to adults in your community?

- Yes*
- No

***C5A.** What type of classes are available for adults? Check all that apply.

- Classes that include on-bike instruction
- Classroom-based classes
- Information sessions/workshops

***C5B.** What topics are covered in these classes? Check all that apply.

- Introduction to bicycling/Learn to ride/Bike handling basics
- Safe riding skills/habits
- Bicycle maintenance
- Sharing the road, trail, or path with vehicles or pedestrians
- Bike commuting basics

***C5C.** Who teaches these classes? Check all that apply.

- League Cycling Instructor
- Local bike shop employee
- Local bicycle advocate
- Local law enforcement officer

***C5D.** On average, how often are these classes offered?

- Monthly or more frequently
- Quarterly
- Semi-annually
- Annually
- Less than annually
- On demand

***C5E.** Are bicycles provided to adults by the community, police, nonprofit or other entity to allow every resident to participate in on-bike instruction?

- Yes
- No

C6. Which of the following communications methods are used to share bicycle information with adults in your community? Check all that apply.

- Community-wide public education campaign
- Community-wide Bicycle Ambassador program
- Educational group rides
- Videos on community website/TV channel/social media
- Bike-specific website or social media accounts for community
- Neighborhood listserves
- Community newsletter (print or digital)
- Community maps (print or digital)
- Handouts or brochures
- Welcome packet for new residents
- Permanent signage, displays, or information kiosks
- Table or booth at community events
- None of the above

C7. Which of the following information is shared using the methods checked above? Check all that apply.

- Introduction to bicycling/Learn to ride/Bike handling basics
- Safe riding skills/habits
- Bicycle maintenance
- Sharing the road, trail, or path with vehicles or pedestrians
- Commuting tips and resources
- Traffic laws/ rules of the road
- Bicycle purchase and fitting guidance
- Equipment, gear, and accessories
- Theft prevention
- Riding in inclement weather
- Family biking
- None of the above

C8. Do any of the above educational classes, resources, or programs for adults specifically target any of the following traditionally-underrepresented groups? Check all that apply.

- Women
- People of Color
- Seniors
- Non-English speakers
- Low-income populations
- University students
- LGBT+ community
- ADA community
- Homeless community
- None of the above

» MOTORIST EDUCATION

C9. In what ways have motorists in your community been educated on sharing the road safely with bicyclists of all ages and abilities? Check all that apply.

- Public service announcements
- Community-wide public education campaign
- Share the Road educational videos on community website/TV channel/social media
- Dedicated Share the Road website or social media sites
- Neighborhood listserves
- Community newsletter/magazine article/blog
- Community maps (print or digital)
- Information in new resident packet
- Information for students and parents from the school system
- Utility bill insert
- Flyer/handout
- Info sessions/lunch seminars
- Billboards
- Share the Road Signs
- Share the Road information in driver's education and testing
- None of the above

C10. Which of the following groups of professional drivers receive training that includes information on sharing the road with bicyclists? Check all that apply.

- Local government staff
- Taxi drivers
- Transit operators
- School bus operators
- Delivery/Commercial drivers
- Emergency vehicle drivers
- None of the above

» BICYCLE SAFETY EDUCATION RESOURCES

C11. How many League Cycling Instructors are active (have taught a class in the last year) in your community? (# only)

C12. Are any of the following educational materials published by the League of American Bicyclists provided to community residents and/or businesses?

- Smart Cycling Quick Guide
- Smart Cycling Student Manual
- Smart Cycling Education videos
- None of the above

» EDUCATION BONUS POINTS

C13. Describe any other education efforts in your community that promote safe cycling. Use this space to expand on answers checked above, or to describe additional educational programs or services that have not yet been covered.

Encouragement

» ENCOURAGEMENT POLICIES, PROGRAMS & PARTNERSHIPS

D1. Which of the following community-wide bicycle encouragement programs or policies exist in your community? Check all that apply.

- Trip reduction ordinance or incentive program
- Guaranteed Ride Home program
- Local business incentive program that rewards customers arriving by bicycle
- Local recognition program for businesses that are bicycle-friendly for their employees and/or customers
- Locally-designated Bicycle Friendly Business District
- None of the above

D1A. Please provide links for any programs checked above:

D2. What other groups actively promote bicycling in the community? Check all that apply.

- Chamber of Commerce
- Downtown Business Association/Business District
- Tourism Board
- Other civic associations (e.g. Rotary, Lion's Club, etc.)
- None of the above

D3. Does your community actively promote the League of American Bicyclists' Bicycle Friendly Business (BFB) or Bicycle Friendly University (BFU) programs in your community?

- Yes
- No

» ROUTE-FINDING SUPPORT

D4. What up-to-date mapping and route-finding information is available for your community? Check all that apply.

- Web-based route finding service
- Smart phone app
- Printed/digital bicycle network map
- Printed/digital mountain bike trails map
- Printed/digital greenways and trails map
- Printed/digital Safe Routes to Schools map(s)
- None of the above

» BICYCLE CULTURE AND PROMOTION

D5. How is National Bike Month/your own dedicated Bike Month promoted in your community? Check all that apply.

Learn about National Bike Month and see the League's National Bike Month Guide for ideas to improve your community's Bike Month efforts.

- Official Proclamation
- Community-wide Bike to Work Day/Week
- Bike to School Day/Week
- Bike to Church Day or similar
- Community Rides
- Mayor-led/Council-led Ride
- Public Service Announcements
- Videos promoting bicycling on community website/TV channel
- Publish a guide or calendar of Bike Month Events
- Bike Month Website
- Commuter Challenge
- Challenges aimed at students biking to school
- Non-commuting related (i.e. errand-running) biking challenges and programs
- National Bike Challenge /Global Bike Challenge
- Bike Commuter energizer stations/breakfasts
- Car-free days
- CycloFemme Ride
- Kidical Mass Ride
- Open Streets/Ciclovia/Sunday Parkways
- Mentoring program for new riders
- Bike valet parking at events
- Bicycle-themed festival/parade/show
- Public education campaign relating to cycling (e.g. with a focus on public health or environmental benefits)
- Trail construction or maintenance day
- None of the above

D6. How is bicycling promoted in your community outside of Bike Month? Check all that apply.

- Community and charity rides
- Mayor-led/Council-led rides
- Videos on bicycling on community website/TV channel
- Public Service Announcements
- Trail construction or maintenance day
- Kidical Mass Ride
- Open Streets/Ciclovia/Sunday Parkways
- Commuter Challenge
- Non-commuting related (i.e. errand-running) challenges and programs
- Challenges aimed at students biking to school
- National Bike Challenge /Global Bike Challenge
- Business program that provides discounts for customers arriving by bicycle
- Triathlons and bicycle races
- Bike commuter events
- Car-free days
- Publish a guide or calendar of community bicycle events
- Mentoring program for new riders
- Bike valet parking at events
- International Bike to School Day in October
- Winter Bike to Work/School Day(s)
- Bicycle-themed festivals/parades/shows
- Public education campaign related to cycling (e.g. with a focus on public health or environmental benefits)
- Community celebration/ride each time a bicycle project is completed
- None of the above

D7. Are any bicycle events specifically marketed to any of the following traditionally underrepresented groups? Check all that apply.

- Women
- People of Color
- Seniors
- Families with toddlers and young children
- Non-English speakers
- Low-income populations (as defined by local regulations)
- LGBT+ community
- ADA community
- Homeless community
- None of the above
- N/A - No bicycle events

D8. How does the municipality sponsor or actively support bicycle events in the community? Check all that apply.

- Organize event(s)
- Fund event(s)
- Contribute in-kind funding (i.e. police presence, closing roads, etc.)
- Assist in promoting event(s)
- None of the above
- N/A - No bicycle events

D9. Are any of the following cycling clubs/groups active in your community? Check all that apply.

- Recreational bike clubs
- Mountain bike clubs
- Cyclocross clubs
- Friends of the Trail groups
- National Mountain Bike Patrol
- Racing clubs or teams
- Kidical Mass, Family Bike Party, or other family-oriented groups
- Senior ride groups
- Women-only ride groups
- LGBT+ ride groups
- People of Color ride groups
- Bike polo/La Crosse clubs
- Slow ride group
- None of the above

D10. Does your community have any of the following youth programs centered on encouraging bicycling for children and youth? Check all that apply.

- Safe Routes to School program
- Trips for Kids chapter
- Earn a Bike program
- Create a Commuter program
- None of the above

» ACCESS TO BICYCLE EQUIPMENT & REPAIR SERVICES

D11. What is the ratio of for-profit specialty bicycle retailers (shops dedicated primarily to selling bikes and bike-related equipment) to population within your community's boundaries?

- 1 shop for every 1-15,000 residents
- 1 shop for every 15,001-30,000 residents
- 1 shop for every 30,001-50,000 residents
- 1 shop for more than 50,001 residents
- There are no specialty bicycle retailers located within the community's boundaries, but there is at least one shop close by.
- There are no specialty bicycle retailers located within or near the community's boundaries.

D12. Is there at least one bike co-op or nonprofit community bike shop within the community's boundaries?

- Yes*
- No

***D12A.** Do(es) the co-op/nonprofit community bike shop(s) receive any of the following support from the local government? Check all that apply.

- Grants
- Free or subsidized property/space for a duration of at least 5 years
- Contracts for services, e.g. bicycle skills or maintenance education, event support, etc.
- Free bicycle safety accessories for distribution, e.g. helmets or lights
- Provision of abandoned or impounded bicycles for resale
- Free PSA or advertising space
- None of the above

» ENCOURAGEMENT BONUS POINTS

D13. Describe any other events, programs or policies your community has to encourage bicycling. Use this space to expand on answers checked above, or to describe additional encouragement efforts that have not yet been covered.

Enforcement & Safety

» PUBLIC OUTREACH

E1. How does your police department interact with the local cycling community? Check all that apply.

- A police officer is an active member of or regularly attends meetings of the bicycle advisory committee
- Identified law-enforcement point person to interact with bicyclists
- Identified law-enforcement point person to Safe Routes to Schools program
- Police department assist with bicycle events/rides
- Police department hosts bicycle events/rides
- Officers provide bike safety education
- Officers distribute bike safety/theft deterrent information
- Police officers report potential hazards to traffic engineers and planners to identify sites in need of safety improvements for bicyclists
- None of the above

E2. What percentage of patrol officers are regularly on bikes?

- None
- 1-20%
- 21-50%
- More than 50%

E3. What other public or private bicycle safety programs are in place? Check all that apply.

- Helmet giveaways
- Light giveaways
- Volunteer trail watch programs/patrols
- None of the above

» BICYCLE-RELATED TRAINING FOR LAW ENFORCEMENT PERSONNEL

E4. What kind of bicycle-related training is offered to police officers? Check all that apply.

- Basic academy training
- International Police Mountain Bike Association training
- Law Enforcement Bicycle Association training
- National Highway Traffic Safety Administration Law Enforcement Training
- Smart Cycling course
- Completion of League Cycling Instructor certification by one or more officers
- Presentation/Training by League Cycling Instructor or local bicycle advocate
- Institute for Police Training and Development bicycle training
- Training on racial profiling awareness in multimodal transportation enforcement
- Training on bicycle crash types, numbers and locations
- None of the above

» BICYCLE-RELATED LAWS

E5. Are there any local ordinances or state laws that protect bicyclists in your community? Check all that apply.

- Specific penalties for failing to yield to a cyclist when turning
- It is illegal to park or drive in a bike lane (intersections excepted)
- Penalties for motor vehicle users that ‘door’ bicyclists
- Ban on cell phone use while driving
- Ban on texting while driving
- Vulnerable road user law
- Safe passing distance law
- It is illegal to harass a cyclist
- Photo enforcement for red lights and/or speed
- None of the above

E6. Do any local ordinances in your community place restrictions on bicyclists? Check all that apply.

- Local law requires bicyclists to use side paths regardless of their usability
- Local law requires bicyclists to use bike lanes when provided
- Local law requires that bicyclists are required to ride as far to the right of the road as practicable without exceptions
- Local law restricts usage of electric-assist bicycles
- Mandatory bike registration
- Mandatory helmet use for all ages
- Restrictions on sidewalk riding outside of the Central Business District
- Restrictions on sidewalk riding inside the Central Business District
- Dismount zones/regulations on shared-use paths
- Local or school policies restrict youths from riding to school
- Bicycles are banned from one or more road that is open to vehicles
- None of the above

» BICYCLE-RELATED ENFORCEMENT PRACTICES & PROGRAMS

E7. Which of the following bicycle-related enforcement practices exist in the community? Check all that apply.

- Data-driven enforcement of traffic violations most likely to lead to crashes, injuries, and fatalities
- Positive enforcement ticketing
- Ticket diversion program for bicyclists
- Ticket diversion program for motorists with educational content specifically related to interacting and sharing the road with bicyclists
- None of the above

E8. How does your community use traffic citation data?

Check all that apply.

- Raw data are published and made available to the public on a regular basis
- Analysis and reports are published and made available to the public on a regular basis
- Data are only available to the public by FOIA request
- Analysis and reports are developed but not shared/are only used internally
- Data/reports are shared with transportation agencies to improve infrastructure
- Data are not collected
- Unknown

» BICYCLE SAFETY POLICIES & PROGRAMS

E9. Is there a specific plan, policy or program to further increase bicycle safety in your community?

- Vision Zero policy/Policy to eliminate traffic fatalities within a specific time frame not to exceed 20 years*
- Towards Zero Deaths program or similar data-driven, interdisciplinary approach that targets areas for improvement and employs proven countermeasures, integrating application of education, enforcement, engineering, and emergency medical and trauma services*
- Traffic safety plan*
- None of the above

***E9A.** Please provide a link or upload the policy/program/plan document.

» CRASH & FATALITY REPORTING

E10. Do police officers report bicyclist crash data?

- Yes*
- No

***E10A.** On average over the past five calendar years, how many bicyclists have been in a crash involving a motor vehicle annually? (# only)

E11. On average over the past five calendar years, how many bicyclists have died due to a crash involving a motor vehicle annually? (# only)

» ENFORCEMENT & SAFETY BONUS POINTS

E12. Describe any other enforcement or safety programs/policies relating to bicycling. Use this space to expand on answers checked above, or to describe additional enforcement or safety programs or policies that have not yet been covered.

Evaluation & Planning

» STAFFING AND COMMITTEES

F1. Is there a bike program manager or primary point of contact for bicycling issues at your local government?

- There is a full-time, paid bike program manager whose primary role is helping the community become bicycle-friendly and encouraging ridership.*
- Promoting bicycling is a part of someone's official job description but they have other responsibilities as well.*
- Helping the community become bicycle-friendly and encouraging ridership is a responsibility shared among multiple staff.
- Promoting bicycling is not a part of anyone's official job description, but at least one staff member has permission to help the community become bicycle-friendly during working hours.
- A citizen volunteer is appointed by the government to help the community become bicycle-friendly.*
- Currently, no one is focused on encouraging ridership or helping the community become more bicycle-friendly.

***F1A.** Provide contact information if different from applicant.

F2. Is there a Safe Routes to School Coordinator?

- There is a full-time, paid Safe Routes to School Coordinator.*
- Promoting Safe Routes to School educational programs and infrastructure improvements is a part of someone's official job description but they have other responsibilities as well.*
- Promoting Safe Routes to School educational programs and infrastructure improvements is a responsibility shared among multiple staff.
- Promoting Safe Routes to School educational programs and infrastructure improvements is not a part of anyone's official job description, but at least one staff member has permission to help the business become bicycle-friendly during working hours.
- A citizen volunteer is appointed by the government to promote Safe Routes to School educational programs and infrastructure improvements.*
- Currently, no one is focused on Safe Routes to School educational programs and infrastructure improvements.

***F2A.** Provide contact information if different from applicant.

F3. How many government employees (including the Bicycle Program Manager and the Safe Routes to Schools Coordinator), expressed in full-time equivalents (FTE), work on bicycle issues in your community? NOTE: A person that spends 1/10 of their time on bicycle issues would be counted as 0.1 FTE. (# only)

F4. Does your local government provide any of the following professional development opportunities for employees who have bicycle-related responsibilities?

Check all that apply.

- League Cycling Instructor (LCI) certification
- Association of Pedestrian and Bicycle Professionals (APBP) membership
- Other professional memberships/accreditations related to bicycles
- Attend bicycle-related webinars/trainings
- Attend bicycle-related conferences
- Present at bicycle-related webinars, trainings, or conferences
- None of the above

F5. Does your community have an officially-recognized Bicycle Advisory Committee?

- Yes*
- No

***F5A.** How often does the committee meet?

- Monthly or more frequently
- Every two months
- Quarterly
- Annually
- Irregularly

***F5B.** Provide contact information for the Bicycle Advisory Committee Chair.

F6. Does your local government have an internal equity, diversity, and inclusion (EDI) initiative, committee, or position?

- Yes*
- No

***F6A.** Provide the name and email address of the primary contact.

***F6B.** Please describe how, if at all, the EDI initiative, committee, or position supports equitable bike planning or outreach in the community.

» PLANNING, FUNDING, & IMPLEMENTATION

F7. Does your community have a comprehensive bicycle master plan or similar section in another document?

- Yes*
- No
- Plan is currently under development**

If yes:

***F7A.** What year was the plan adopted?

***F7B.** Provide a link to the plan.

***F7C.** Is there a dedicated budget for implementation of the plan?

- Yes***
- No

*****F7C1.** What is the designated annual budget? (If budget is not consistent annually, provide the annual average from the last 10 years or length of plan.) (# only)

*****F7C2.** List or describe funding source(s).

***F7D.** Does your plan include a goal to increase bicycle facilities?

- Yes*
- No

***F7D1.** Please list or describe these goals.

***F7E.** How have community planning staff reached out to minority, non-English speaking, and/or low-income communities to ensure that they are included in the decision-making process?

If Plan is currently under development:

****F7F.** Is there a planned budget for implementation of the plan?

- Yes***
- No

*****F7F1.** What is the planned annual budget? (# only)

****F7G.** How are community planning staff reaching out to minority, non-English speaking, and/or low-income communities to ensure that they are included in the decision-making process?

Existing questions that were modified after comparison to past Benchmarking Report questions are highlighted in GREEN.

F8. What other local agencies have a bicycle master plan or similar section in another transportation demand management document? Check all that apply.

- Transit agency
- School district
- Higher education institution(s)
- Hospital or medical center(s)
- Parks & Recreation
- Metropolitan Planning Organization
- Regional Planning Commission
- County/Borough/Parish
- None of the above

F9. Is community-wide bicycle planning integrated with planning for any of the following: Check all that apply.

- Transit stops
- Public & private schools (K-12)
- Higher education institutions
- Hospitals and medical centers
- Parks & recreation centers
- Subsidized or public housing
- None of the above

F10. What percentage of the community's total annual transportation budget – on average over the last five fiscal years – was invested in bicycle projects? (drop-down menu: “unknown” and 0-100% options)

F11. Is bicycle-related funding specifically allocated to underrepresented areas of your community? (E.g. low-income neighborhoods, etc.)

- Yes*
- No

***F11A.** Please describe.

F12. How many lane miles of planned bicycle facilities does your community expect to have installed in the next four years? (# only) Write “0” if there are no specific goals or plans for additional bicycle facilities to be installed in the next four years.

F13. How many lane miles of bicycle facilities has your community installed in the last two years? (# only) Write “o” if no new bicycle facilities have been installed in the last two years.

» EVALUATING RIDERSHIP

F14. How does your community collect information on bicycle usage? Check all that apply.

- Automated /electronic bicycle counters
- Regular statistically-valid community bicycle surveys
- Travel diaries
- Household travel surveys that include bicycle trips
- App-based or other opt-in electronic data collection (e.g. Strava, Zap, etc.)
- Regular manual counts of bicyclists on trails
- Regular manual counts of bicyclists on the road
- Regular counts of parked bicycles at transit stations (if applicable)
- Regular counts of parked bicycles at schools
- Regular counts of parked bicycles at other destinations (downtown business district, etc.)
- Manual counts that include demographic data collection (e.g. gender, race, age, etc.)
- Manual counts that specifically target traditionally underrepresented neighborhoods
- Cordon counts that include bicyclists
- Any other type of count that includes bicyclists
- None of the above

If the community has collected ridership data locally for any of the following categories, please provide up to one PDF or excel file for each category where ridership data are available: (file uploads only available through online application – additional files may be uploaded at the end of the application.)

F14A. Utilitarian ridership data collected locally (e.g. bicycle rides for commuting, running errands, transportation, etc.)

F14B. Recreational ridership data collected locally (e.g. rides solely for exercise or fun.)

F14C. Demographic ridership data collected locally (e.g. rider age, race, gender, etc.)

F14D. School ridership data collected locally (e.g. rides by or with K-12 or younger children – either riding on their own or being carried in a child seat, trailer, etc.)

F14e. Other ridership data (e.g. any other bicycle ridership data collected locally that doesn't fall under the above categories.)

F15. Does your community establish target goals for bicycle use? (E.g. a certain level of bicycle mode share)

- Yes*
- No

***F15A.** Please list or describe these goals.

» EVALUATING THE BICYCLE NETWORK

F16. Does your community routinely conduct pre/post bicycle mode share evaluations of bicycle-related road projects?

- Yes
- No

F17. Which of the following mechanisms are in place for bicyclists to identify problem areas or hazards to traffic engineers, planners, and police? Check all that apply.

- Online reporting system (e.g. SeeClickFix)
- Mobile app
- Hotline
- Regular meeting
- Contact directly via call/voicemail/fax/email/text/social media
- None of the above

F18. How has your community conducted a network analysis to evaluate current conditions for bicyclists and identify significant infrastructure barriers to bicycling? Check all that apply.

- GIS-based network analysis
- Level of Traffic Stress analysis
- Bicycle Level of Service for roads
- Bicycle Level of Service for intersections
- Multimodal Level of Service
- None of the above

Existing questions that were modified after comparison to past Benchmarking Report questions are highlighted in GREEN.

» EVALUATION & PLANNING BONUS POINTS

F19. Besides the Bicycle Friendly Community program, what other national programs does your community participate in to improve for bicycling? Check all that apply.

- U.S. DOT Mayor's Challenge for Safer People and Safer Streets
- National League of Cities/Let's Move! Cities, Towns and Counties
- LEED® for Neighborhood Development
- NACTO Cities for Cycling
- None of the above

F20. Describe any other efforts by your community to evaluate and/or plan for bicycle ridership and/or networks. Use this space to expand on answers checked above, or to describe any additional evaluation & planning efforts that have not yet been covered.

Final Overview

G1. What are the top three reasons your community has made bicycling a priority? Click up to three.

- Improved quality of life
- Improving public health
- Community connectivity
- Provide affordable transportation options
- Reduce car-parking demands
- Climate change/environmental stewardship concerns
- Decrease traffic congestion
- Increase tourism
- Increase property values
- Cooperation with adjacent communities
- Public demand
- Economic development
- Support Smart Growth or other growth management goals
- Traffic and bicycle/pedestrian safety
- Meet local or state requirements
- None of the above

G2. Briefly describe the most positive outcome of your community's support for bicycling.

G3. Describe any improvements that have occurred for cycling in your community since your last application. (Write N/A if this is your first time applying.)

G4. What could be done differently in order to make bicycling safer, more enjoyable and/or more convenient in your community?

G5. What specific bicycle-related improvements are planned in the next 12 months that directly affect your community?

G6. We often get requests for example BFC applications from aspiring communities. Are you willing to share your application?

- Yes
- No

G7. How did you hear about the Bicycle Friendly Community program?

Supplementary Benchmarking Report City Survey

****These supplementary questions are only required if you are participating in the 2018 Bicycle & Walking Benchmarking Report (BMR) Project. Learn more at <https://bicyclefriendly.secure-platform.com/a/page/community/BMR>.

» (BMR) ENGINEERING

BM1. How many miles of public sidewalks are within your community? *Public sidewalks are paved paths within the roadway right-of-way that are designed for pedestrian use. Often, bicycling is not allowed and the pavement is less than 8 feet wide. Please answer in lane miles.*

Existing questions that were modified after comparison to past Benchmarking Report questions are highlighted in GREEN.

» (BMR) EDUCATION

BMR2. What percentage of your public and private schools (elementary, middle, and high) offer pedestrian safety education?

- 1-25%
- 26-50%
- 51-75%
- 76-100%

BMR3. Outside of schools, are pedestrian safety skills taught to children and youth by city-sponsored programming?

- Yes
- No

» (BMR) ENFORCEMENT & SAFETY

BMR4. What percentage of Emergency Medical Technicians or paramedics are regularly on bikes?

- None
- 1- 20%
- 21-50%
- More than 50%

BMR5. What percentage of patrol officers are regularly on foot?

- None
- 1- 20%
- 21-50%
- More than 50%

BMR6. What percentage of Emergency Medical Technicians or paramedics are regularly on foot?

- None
- 1- 20%
- 21-50%
- More than 50%

BMR7. Does your city require motorists to yield to pedestrians?

- Yes*
- No

***BMR7A.** If yes, what is the monetary penalty for a motorist who fails to yield to a pedestrian?

» (BMR) EVALUATION & PLANNING

BMR8. How many government employees (including the Pedestrian Program Manager and the Safe Routes to Schools Coordinator), expressed in full-time equivalents (FTE), work on pedestrian issues in your community?

NOTE: A person that spends 1/10 of their time on bicycle issues would be counted as 0.1 FTE. Please do not double count any employee time reported in Question F3 under BFC: Evaluation & Planning. (# only)

BMR9. How many lane miles of planned pedestrian facilities does your city expect to have installed in the next four years? (# only)

BMR10. How many lane miles of pedestrian facilities has your city installed in the last two years? (# only)

BMR11. Which of the following plans has your city adopted? Please include any bicycle master plans already mentioned in Question F3 under BFC: Evaluation & Planning. Check all that apply.

- A combined bicycle and pedestrian master plan
- A standalone bicycle master plan
- A standalone pedestrian master plan
- A trails master plan
- A mountain bike master plan
- None of the above

BMR12. Which of the following goals has your city published as part of any adopted plan? Check all that apply.

- Increase pedestrian facilities
- Increase bicycling facilities
- Increase walking
- Increase biking
- Increase physical activity
- Decrease pedestrian fatalities
- Decrease bicyclist fatalities
- Decrease pedestrian injuries
- Decrease bicyclist injuries
- None of the above / N/A - no plan

BMR13. Has your city adopted any of the above goals as part of any of the following plans? Check all that apply.

- A carbon emissions reduction plan
- A public health improvement plan
- A transportation congestion mitigation plan
- A public safety improvement plan
- None of the above

BMR14. What percentage of the community's total annual transportation budget – on average over the last five fiscal years – was invested in pedestrian projects?

If you are unable to differentiate between bicycle and pedestrian budgets, please include the total bike/ped budget in F10 under BFC: Evaluation & Planning, and enter "unknown" here.

(drop-down menu: "unknown" and 0-100% options)

BMR15. How does your community collect information on pedestrian trips? Check all that apply.

- Automated /electronic pedestrian counters
- Regular statistically-valid community pedestrian surveys
- Household travel surveys that include pedestrian trips
- Regular manual counts of pedestrians on trails
- Regular manual counts of pedestrians within roadway right-of-way (e.g. on sidewalks or shared space)
- Manual counts that include demographic data collection (e.g. gender, race, age, etc.)
- Manual counts that specifically target traditionally underrepresented neighborhoods
- App-based or other opt-in electronic data collection (e.g. Strava, Zap, etc.)
- Cordon counts that include pedestrians
- Any other type of count that includes pedestrians
- None of the above

» ALTERNATIVE MINIMUM BENCHMARKING SURVEY FOR CITIES

The alternative minimum benchmarking survey for cities was distributed to cities that did not complete any other survey in an attempt to update as much data as possible. Full or partial responses to this alternative minimum survey allowed the 2018 Benchmarking Report to provide updated data for 10 cities.

Bicycle & Pedestrian Infrastructure

1 » Please report the number of lane miles of protected bike lanes in your city (also called cycle tracks, separated bike lanes, or buffered bike lanes).

For the purpose of this question, protected bike lanes are bicycle-only lanes that are on or adjacent to the roadway, separated from motorized vehicles with a physical barrier, such as bollards, curb, raised pavement or painted buffer zone.

Lane miles are measured the total length and lane count of a protected bicycle facility. Lane miles are calculated by multiplying the centerline mileage of a bike lane by the number of lanes it has (e.g. a two-way cycletrack has two lanes).

2 » Please report the number of lane miles of unprotected bike lanes in your city.

For the purpose of this question, unprotected bike lanes are bicycle-only lanes that are on a roadway, designated with a painted stripe, next to motorized traffic lanes. They are not protected with a physical barrier or painted buffer zone.

3 » Please report the number of lane miles of public sidewalks in your city.

For the purpose of this question, public sidewalks are publicly owned paved paths within the roadway right-of-way (ROW) that are designed for pedestrian use. Usually, bicycling is not allowed*

4 » Please report the number of lane miles of paved public paths in your city.

For the purpose of this question, paved public paths are publicly owned paths outside the roadway right-of-way (ROW), open to both bicycling and walking, but closed to motorized vehicles.

City Budget for Biking & Walking

5 » Does your city have an overall bicycle and pedestrian spending target?

Yes/No/Other

6 » If your bicycle and pedestrian spending target is expressed as a percentage, what is the current target as a percentage (%) of the city's transportation budget?

7 » If your bicycle and pedestrian spending target is expressed as a dollar value, what is the current target as a dollar value?

8 » How much did your city budget for transportation programs overall in the last fiscal year?

9 » Please indicate the amount in dollars dedicated to bicycle and pedestrian programs in the last fiscal year.

10 » Please indicate the amount in dollars dedicated to other transportation programs (not including bicycle and pedestrian programs) in the last fiscal year.

11 » Please indicate the last fiscal year used to answer the two preceding questions.

12 » Expressed in Full-Time Equivalents (FTE), how many city employees and regularly hired contractors worked on bicycle and/or pedestrian issues as detailed in their job description in the last two years?

For the purpose of this question, a FTE is a person or combination of persons who works 2,000 hours over the course of a year (2,000 hours = 1 FTE). Safe Routes to School program work should be included as bicycle and pedestrian work.

City Goals & Plans

13 » Please indicate whether your city has adopted goals to do any of the following things through a publicly available document.

- Goal to increase bicycle facilities
- Goal to increase pedestrian fatalities

- Goal to increase bicycling (defined in trips, modeshare, or any other metric)
- Goal to increase walking (defined in trips, modeshare, or any other metric)
- Goal to increase physical activity (defined by any metric)
- Goal to decrease pedestrian fatalities
- Goal to decrease bicyclist fatalities

City Activities

14 » Please indicate whether any of the following education activities were available in your city in the past two years.

- Youth bicycle education
- Adult bicycle education
- Youth pedestrian education

15 » Was at least one Bike to Work Day event hosted in your city in the past two years?

Yes/No

16 » Did your city host an open streets initiative (also known as "ciclovía," "Sunday Streets," or "Saturday Parkways") in the past two years?

For the purpose of this question, an open streets initiative is a program that regularly closes one or more streets to motorized traffic and encourages pedestrian and bicyclist use of the street(s). Please do not include one-time events such as marathons, bike races, or festivals. Yes/No

Bikeshare

17 » Does your city currently have one or more public bike share program(s)?

For the purpose of this question, a public bike share program is a publicly or privately funded program that allows members of the general public to rent a bicycle that is allowed to be parked on public property or use such a bicycle through a membership in the program.

- Yes, my city has a public bike share program
- Yes, my city has more than one public bike share program
- No, my city does not have any public bike share program as described for this question

18 » How many bicycles are available to be rented by the public in your city at any given time?

For the purpose of this question, if your city has multiple public bike share programs then the total of all programs should be reported.