MPC-455

April 1, 2014- July 31, 2017

**Project Title:**

Why Are Bike-Friendly Cities Safer for All Road Users?

**University:**

University of Colorado Denver

**Principal Investigator:**

Wesley Marshall, PhD, PE  
Asst. Professor  
University of Colorado Denver  
Department of Civil Engineering

303-352-3741

wesley.marshall@ucdenver.edu

**Co-Principal Investigators:**

Carolyn McAndrews, PhD, MCP, MS

Asst. Professor

University of Colorado Denver

Department of Planning and Design

303-315-0028

carolyn.mcandrews@ucdenver.edu

Krista Nordback, PhD, PE  
Research Associate

Oregon Transportation Research and Education Consortium (OTREC)

Portland State University

503-725-2897

nordback@pdx.edu

Bruce Janson, PhD, PE  
Professor  
University of Colorado Denver  
Department of Civil Engineering

303-556-2831

bruce.janson@ucdenver.edu

**Research Needs:**

Bicycling as a fundamental mode of transportation is being reinvented in the United States. On one hand, Americans are becoming increasingly reliant on bicycling, as evidenced by the 61% increase in bicycling to work between 2000 and 2010 ([U.S. Census Bureau 2013](#_ENREF_35)). At the same time, more and more U.S. cities are improving their bicycling infrastructure. For instance, the number of protected bike lanes in the U.S. increased by almost 65% in 2012 alone ([Snyder 2013](#_ENREF_33)). Despite these changes, a recent bicycling safety report from the Organization for Economic Cooperation and Development (OECD) states that Americans still bicycle less than residents of the other 33 OECD countries. Moreover, Americans are also among the most likely to die as bicyclists ([OECD and International Transport Forum 2013](#_ENREF_29)).

Just how dangerous is bicycling? Given the lack of exposure data and bicycling counts in the U.S., this is a difficult question to answer definitively. However, we will attempt to estimate the relative safety of bicycling in the U.S. as compared to driving. For instance in the U.S. in 2012, 33,561 people were killed in motor vehicle crashes, of which 726 involved a bicycle. In 2012, Americans drove 2,938,535 million miles, which equates to a fatality rate of 1.14 fatalities per 100 million VMT ([FHWA 2013](#_ENREF_9)). With respect to bicycling, the National Sporting Goods Association reports that 39.3 million Americans aged 7 or older rode a bike in 2012 ([National Bicycle Dealers Association 2012](#_ENREF_24)). So given that number of bicyclists and the 726 bicyclist fatalities in 2012, each bicyclist would have to bike more than 1,600 miles each year to achieve a better fatality rate than those in motor vehicles. This would mean that the 12.5% of Americans who bike were bicycling 4.5 miles every day of the year. While this level of bicycling would be encouraging on many fronts, it is not a realistic level of bicycle exposure in the U.S. context given current travel patterns ([Mapes 2009](#_ENREF_19)). Another bicycling safety estimate from Pucher and Dijkstra approximated bicycling exposure from commute data and found that the per-mile fatality rate for drivers in the U.S. was approximately ten times lower than that for bicyclists ([Pucher and Dijkstra 2003](#_ENREF_32), [Mapes 2009](#_ENREF_19)). Either way, these estimates suggest that there is a much higher chance of a fatality per mile cycled than per mile driven.

Transit, on the other hand, has been shown to be a much safer mode of transportation than driving. Recent numbers suggest fewer than 0.06 fatalities per 100 million passenger transit miles traveled, which is approximately nineteen times safer than driving ([Politifact.com 2011](#_ENREF_30)). Given this difference between transit and automobile safety, it would stand to reason that cities with a high percentage of people traveling by transit would be safer overall than the typical automobile-based city. This trend turns out to be the case. In an international study, Kenworthy and Laube concluded that cities with higher transit use also tended to have lower overall fatality rates ([Kenworthy and Laube 2000](#_ENREF_15)). Litman, in a separate analysis, found that the per capita fatality rates of U.S. cities were lower with increased transit use and that residents of automobile-oriented cities had a traffic fatality rate five times that of those living in transit-oriented communities ([Litman 2009](#_ENREF_17), [2013](#_ENREF_18)). One reason behind these results is that more transit use tends to also lower the overall level of vehicle use. Another explanation is that transit use is higher in relatively dense metropolitan areas with urban forms designed for relatively slow speeds, thus reducing the number of deaths of travelers by just about any mode.

So given these safety trends, one might conclude that bicycling-based cities must be far more dangerous than either transit-based cities or automobile-based cities. However, the evidence strongly points to the fact that cities known for their bicycling are not just safer for bicyclists but for all road users ([Marshall and Garrick 2011](#_ENREF_21)). For instance, the U.S. city with the greatest percentage of people bicycling to work – Davis, California – endured only nine fatal road crashes over a recent twelve year period. Only three of those fatalities occurred on non-limited access streets, and not one involved a bicyclist. These results equate to a fatal crash rate of less than 1.5 per 100,000 residents. With the current per capita crash rate in the U.S. more than seven times higher at 10.7 fatalities per 100,000 residents, it is easiest to discount Davis as an outlier. Yet, Davis is not alone. Another city that has become renowned for its bicycling over the last twenty years – Portland, Oregon – has concurrently improved its road safety record. Between 1990 and 2010, Portland’s bicycle mode share increased from 1.2% to 6.0%; at the same time, the total number of road fatalities in Portland dropped by 75% over the last ten years with no bicyclist fatalities in more than half of those years ([City of Portland Bureau of Transportation 2011](#_ENREF_2)). This is a remarkable safety record (4.5 fatalities per 100,000 residents for 2010) for a city of over 580,000 people and is only comparable internationally to countries reporting the lowest crash rates in the world such as the Netherlands at 4.0 per 100,000 residents ([OECD 2011](#_ENREF_28)). Perhaps not coincidentally, the Netherlands also boasts a bicyclist mode share of 27% ([Pucher and Bueler 2008](#_ENREF_31)).

Examples such as Davis, Portland, and the Netherlands are often written off as outliers because their cultures of bicycling have been prevalent for decades. New York City, however, is a relative newcomer to the bicycling experiment, having installed over 350 lanes miles of bike lanes since 2006 ([New York City DOT 2013](#_ENREF_25)). Over the last five years, bicycling has nearly doubled in New York City while traffic deaths are down more than 30% ([Donohue 2013](#_ENREF_5), [Miller 2013](#_ENREF_23)).

Despite conventional logic, the evidence continues to build that bike-friendly places are not only safer for bicyclists but for all road users. The motivating question for this research, however, is: why is this the case?

A handful of existing studies have tackled the bicyclist ‘safety in numbers’ concept where individual bicyclist risk drops with an increasing number of bicyclists ([Ekman 2006](#_ENREF_6), [Jacobsen 2003](#_ENREF_13), [Jensen 2002](#_ENREF_14), [Nordback and Marshall 2010](#_ENREF_26), [Nordback, Marshall, and Janson 2013](#_ENREF_27)). The rationale most often given for this safety benefit is a shift in driver expectations and behavior based upon the perceived possibility of encountering a bicyclist. However, these studies only attempt to understand the difference in bicyclist safety. Far fewer studies have investigated the safety effect of a bike-friendly city on the safety of all road users ([Marshall and Garrick 2011](#_ENREF_21)).

Beyond safety in numbers, there are other theories as to why these places seem to be safer for all road users. Accordingly, we hypothesize the following four pathways through which high-bicycle-mode-share cities improve transportation fatality rates for all road users:

1. Socio-demographic and socioeconomic changes, as cities become more populated by those with generally lower transportation injury risks;
2. Built environment changes, as cities promoting bicycling create streets and land use patterns;
3. Travel behavior changes, as the shifting demographics, incomes, and land use patterns help reduce exposure; and
4. Traffic and operation changes, as the above differences help promote lower speed environments.

This will be the first research study to attempt disaggregate and understand what makes these high-bicycle-mode-share cities safer for all travelers, the differential impact of these various influences, and the interactions of these variables on different groups of road users.

**Research Objectives:**

This study will:

1. Identify the influence of socio-demographic and socioeconomic changes in cities experiencing a concurrent increase in bicycling and improvement road safety;
2. Characterize the influence of built environment changes in these cities;
3. Investigate the relationship between evolving travel behaviors and overall road safety;
4. Explore potentially novel sources of citywide travel speed data and pilot a study looking at the potential for systematic differences in travel speed with respect to road safety outcomes;
5. Advance knowledge by carrying out analyses to answer research questions 1–4;
6. Advance policy and practice by identifying important explanatory variables with respect to building safer cities;
7. Advance education through the training of students; and
8. Build an evidence base on a novel topic by share findings through publications, presentations, and a project website.

**Research Methods:**

To answer the research questions above, we will carry out a longitudinal analysis of traffic fatality rates in cities and regions with and without high-bicycling mode share. A longitudinal study provides insight into the potential causal factors underlying changes in transportation safety outcomes. Our study design includes the following steps: i) preliminary data collection; ii) site selection; iii) supplemental data collection; iv) built environment measurement; v) statistical data analysis; and vi) dissemination.

*Preliminary Data Collection*

The initial data collection effort will commence by collecting data from 1990 to the present day from the Fatality Analysis Reporting System (FARS) database and the U.S. Census. 1990 was selected as the starting point, as that was the first year that bicycle journey to work data was collected by the U.S. Census.

FARS is a national repository for fatal traffic crashes collected and maintained by the National Highway Traffic Safety Administration (NHTSA). We are focusing on fatal crashes for variety of reasons. One is that we want to maintain consistency in the data, and traffic crash severity levels often vary from state to state. Second, a focus on fatalities limits the bias caused by a known underreporting of bicycle and pedestrian injuries sustained in traffic ([Mapes 2009](#_ENREF_19)). Third, we also expect the results to speak to traffic safety as a public health outcome. Property damage only crashes, which constitute the majority of crashes in most traffic safety studies, do not necessarily help in understanding safety as a health impact. We expect to add injury crashes in future research on this topic.

U.S. Census data will be collected at the Census Tract level of analysis. This data will include population and demography data, including socioeconomic and socio-demographic factors such as income, race/ethnicity, and education. It will also include travel behavior data such as commute mode share and travel time to work. As part of this effort, we will study the correlation between bicycling and walking to work. If deemed sufficient, we may look to take our data collection back before 1990.

*Site Selection*

Based upon a preliminary data analysis of the above data, we will select a minimum of eight major US. cities/regions, including a minimum of two from the Mountain Plains Consortium region. The fundamental intent is to divide our selected cities into those that have experienced substantial growth in bicycling over the last two decades and those that have not. Because we want to understand the influence of socio-demographic and socioeconomic changes on safety, we are looking for these variables to be relatively similar across our selected cities toward the beginning of our timeline.

For research question number four regarding the influence of speed, we will select two cities from the overall set. The reasoning behind this subset has to do with data limitations, as actual speed data at the level of geography we are looking for is difficult to acquire across an entire city, particularly longitudinally. Thus, the speed portion of the overall study will focus on evaluating the viability of various data sources and serve as a pilot study for an area-based, speed investigation.

For instance, recent discussions with the AirSage CEO, Cy Smith, suggest that travel speed data may be able to be derived from their point-level location data. AirSage specializes in wireless network signaling data and boasts the broadest and most extensive coverage of real-time cellular data. Their data agreements with some of the major cell phone companies in North America enable them to anonymously collect location data for over fifteen billion points each day. While this data has been used in transportation research before, it has primarily been in planning models and the creation of origin-destination matrices. Accordingly, our focus for research question number four will be on investigating such novel data sources and comparing them with more conventional – and typically arduous – methods of collecting travel speed data across large area.

*Built Environment Measurement*

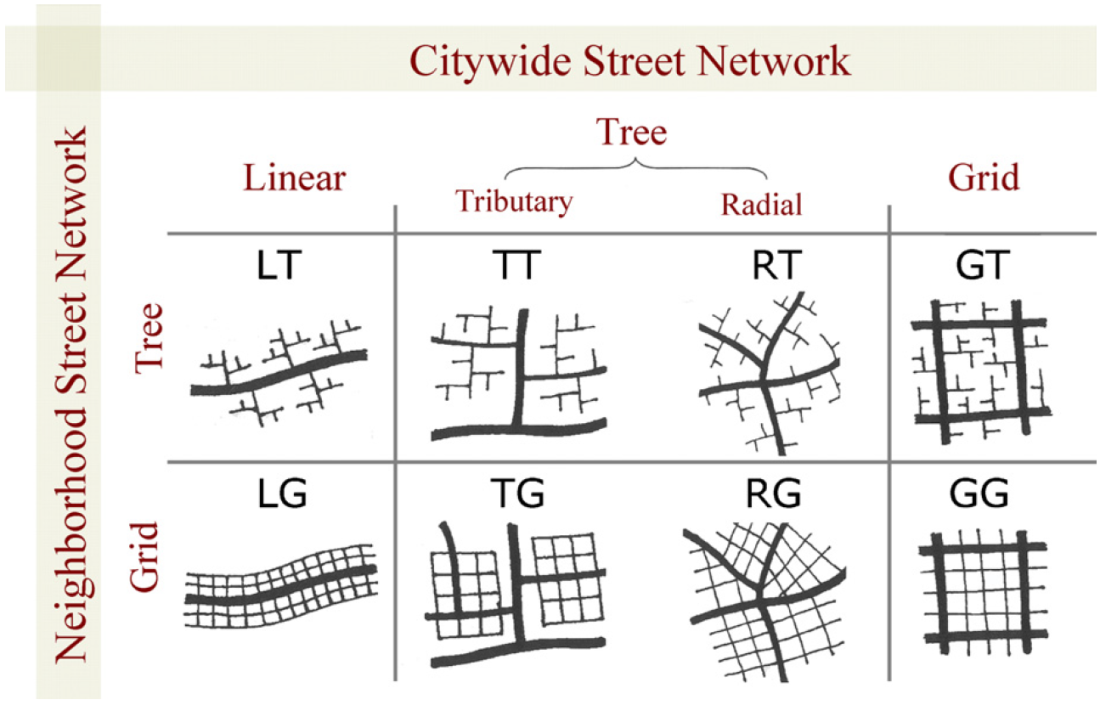
Our next data collection effort will first focus on built environment data. Our main source for this data will be publically available GIS data. This database will be supplemented through a combination of historical aerial images and background research related to when specific infrastructure elements were added or changed over the study time period. All elements will be geocoded in GIS and coded for our statistical analyses.

While many urban planners point to both increased network density and connectivity as desirable, few successfully differentiate between these two network qualities with quantifiable measures ([Marshall and Garrick 2012](#_ENREF_22)). To best characterize street networks, we will use a straightforward set of measures for the three essential street network characteristics of interest:

1. Street connectivity
2. Street network density
3. Street configuration

While there are abundant indices, ranging from very simple to overly complex, available to measure both connectivity and network density, we anticipate using intersection density for street network density and the link to node ratio for street connectivity. Intersection density tallies the total number of nodes or intersections, including dead ends, and divides it by the area. Higher values signify higher network densities. The link to node ratio divides the total number of links (i.e. road segments between intersections) by the total number of nodes (i.e. intersections) ([Ewing 1996](#_ENREF_7), [Litman 2005](#_ENREF_16), [Handy, Paterson, and Butler 2003](#_ENREF_11)). Many researchers and practitioners use a score of 1.4 as the threshold of high connectivity with higher values indicating more connectivity ([Handy, Paterson, and Butler 2003](#_ENREF_11)). We intend to calculate both intersection density and the link to node ratio for the typical automobile street network as well as for the same network but including pedestrian- or bicycle-only connections and alleys as well (alleys are included in the intersection density measure used by LEED-ND ([Council 2009](#_ENREF_4))). The data necessary for calculating the pedestrian- and bicycle-level networks can often be derived from a merging of various data sources such bicycling maps provided by the cites or GIS data such as the Open Street Map.

Neither intersection density nor the link to node ratio imparts any sense of configuration. Accordingly, we will adapt a chart derived from Stephen Marshall’s book *Streets and Patterns* that emphasizes the major street network structure separately from the minor street network, depicted in the figure below ([Marshall 2005](#_ENREF_20)). To facilitate replication, major streets will be classified as those falling between A20 and A39 under the Feature Class Code (FCC) classification schema used by the Census. The A20 series includes all primary roads without limited access while the A30 series includes all secondary or connecting roads; in other words, the major streets are essentially the arterial and collector roads. Understanding the role of the major streets in the network will help facilitate classification of the many Census Tracts into one of the eight representative configuration types. Although Marshall’s categories do not accommodate every possible pattern, they do provide a straightforward visual classification that can help differentiate between the most common configuration types. While actual street networks were not always exact replicas of the representative diagrams, a previous study of American cities found only a handful of the over 1,000 zones were not able to be confidently classified.



**Minor Street Network**

**Major Street Network**

**Figure 1 - Street Configuration Classifications (adapted from Marshall 2005)**

The result of the street network analysis will be a quantifiable assessment of the fundamental infrastructure differences among our case study cities. This methodology will also enable us to quantify the structural differences between car networks and bicycle/pedestrian networks.

We will supplement the built environment database with land use data. Our preliminary investigation finds that very few cities maintain the sort of longitudinal land use data we would want for this research. Our current substitute is to collect raster GIS data from the National Land Cover Database (NLCD). With this data, we will be able to distinguish the natural environment from the built environment, as well as the relative intensity of that built environment. With the NLCS, we will be able to make these assessments longitudinally. Combined with longitudinal population and employment numbers, we expect to be able to account for land use changes as well as infrastructure changes with respect to safety.

*Statistical Data Analysis*

The literature suggests that a longitudinal study, where we are also interested in cross-locational issues, can be conducted using a panel data model ([Ahangari et al. 2014](#_ENREF_1)). This methodology is not uncommon to studies examining the relationship between traffic fatalities and explanatory variables ([Cotti and Tefft 2011](#_ENREF_3)). Since we are using fatality rate as the dependent variables instead of a crash count, the city-level model takes the following log transformational form because fatality rate has no discrete value ([Ahangari et al. 2014](#_ENREF_1)):

with:

FatalityRate = road fatality rate per 100,000 population;

X = set of transportation behavior variables;

Y = endogenous built environment variables;

Z = socioeconomic / socio-demographic variables;

α, β, γ = coefficients of X, BY, and Z;

(AX =F) represents the fixed effect for each city;

= time dummy variable; and

= error term for city i at time t.

Panel data models also are useful in picking up effects from omitted variables such as infrastructure conditions, enforcement differences, and technological changes ([Ahangari et al. 2014](#_ENREF_1)). For the sake of the equation above, we assumed a fixed effects model; however, if the omitted variables do not correlate with independent variables, then a random effects model will be used.

We will also employ a multilevel negative binomial model with fatality counts as the outcome variable. For this Census Tract level research, our data is considered multilevel since it consists of records on the first Census Tract level that can be clustered into a second level of geography, in this case, at the city level. The concept behind a multilevel hierarchical model is linking a pair of statistical models in order to simultaneously allow a focus on both micro-level and macro-level relationships as well as the interaction between the two ([Healy 2001](#_ENREF_12)). This type of structure helps account for spatial autocorrelation and the fact that respondents in the same areas tend to share the characteristics of those areas, which would violate the independence assumption of an ordinary least squares (OLS) regression ([Ewing et al. 2003](#_ENREF_8)). If we did not take this into account, the standard errors of regression coefficients that we are seeking to associate with our characteristics would likely be underestimated ([Ewing et al. 2003](#_ENREF_8)).

The following represents the hierarchical structure:

Level 1: Between-Census Tract Disparities

Level 2: Between-City Differences

The first level of the model includes the safety outcomes, socioeconomic / socio-demographic data, and built environment characteristics of each Census Tract, which can be modeled as a function of the characteristics of the Census Tract plus stochastic random error ([Ewing et al. 2003](#_ENREF_8)). This equates to each city having a specific regression equation portraying the association between the characteristics and safety outcomes of the Census Tract. For the second level, the city-specific intercept and coefficients are modeled in terms of city characteristics plus random error ([Ewing et al. 2003](#_ENREF_8)).

The level 1 model tested safety outcomes as a function of the city mean using the following form:

Yji = β0j + β1jxij + rij rij ~ N(0, σ2)

where Yji is the outcome for Census Tract i in city j, and xij is an fixed covariate. β0j represents the mean level of the outcome in city j, and β1j represents the effect of the Census Tract-level variable on the outcome in city j.

The expected random effects level 2 model allows the intercept and slope to vary across cities. The level 2 model corresponding to a level 1 random coefficients model is as follows:



where γ00 represents the overall average outcome level (at xij = 0), and γ10 is the average effect of Census Tract variables on the outcomes. Also, the city level data will be added as fixed effects in this model in order to permit for the potential varying and cross influence of Census Tract level and city level characteristics. For instance, one could imagine that living in a compact and connected Census Tract might make more of a difference in a city of similar structure as compared to a city characterized by a sparse, disconnected street network; this modeling structure facilitates the testing of such questions.

The variables used in all of the final models will be selected in an effort to maximize model significance using the AIC value.

*Dissemination*

Dissemination of results from this project will target both academic and practitioner audiences. To reach academic audiences, we will produce conference presentations and peer-reviewed journal papers to share findings of this project. Yet, even the best transportation research is of little value until that knowledge is effectively shared with a broader audience. Accordingly, we will also write articles for practitioner audiences, popular press articles, and create a project website. With respect to writing popular press and newsletter articles, we have found this step to be an integral element of dissemination with past projects and have written numerous such articles. Also, a project website will provide a permanent home for the project results, social media interaction among interested parties, and eventually include the GIS map application.

The web-based GIS tool will help make the research outcomes as accessible as possible. We will realize this by web deploying a GIS system that will enable users to: i) investigate the various study cities, ii) compare the historical transportation mode choice, built environment, and socioeconomic/socio-demographic changes to these cities; and iii) visualize the road safety results. The general steps to deploying a web application involve: preparing data, creating a map service, creating a web application, and creating user tools. The plan is to enable users to create maps that can be shared through social media, embedded in websites, and be accessible on cell phones and tablets without additional effort on the users’ part.

**Expected Outcomes:**

The expected outcomes of this work include:

1. Findings with respect to the testable hypotheses and research questions;
2. A set of explanatory and dependent variables and constructs where we can disaggregate the factors influencing better road safety for all road users in bicycle-friendly cities;
3. A project website with web-based GIS mapping tools;
4. Manuscripts for presentation/publication at TRB and manuscripts for other peer-reviewed journals;
5. Presentations to academic and policy audiences; and
6. A module about road safety, active transportation, street networks for transportation courses at the University of Colorado Denver.

**Relevance to Strategic Goals:**

The work primarily falls under the heading of safety, but it also highly relates to livable communities in terms of physical activity and environmental sustainability. The project also specifically concerns one of the priorities of the new U.S. DOT administration. In his remarks to the TRB Chairman’s Luncheon at TRB on January 15, 2014, Department of Transportation Secretary Foxx cited his transportation priorities, which included a new focus by his administration on bicycle and pedestrian safety ([Foxx 2014](#_ENREF_10), [Snyder 2014](#_ENREF_34)).

**Educational Benefits:**

This study will be integrated into Dr. Marshall’s “Case Studies in Sustainable Transportation” and Dr. McAndrews’ “Transportation Policy and Planning” graduate courses through a case study approach that will present research materials to the students and be incorporated into student term projects. These transportation courses are based in the Civil Engineering Department and the Department of Planning and Design, respectively.

The data collected for this project will also be made available to students for use in term projects and/or master’s reports. As a result, this project will influence students from a variety of disciplines that comprise our future transportation professionals. Students who work on the project will have the opportunity to be co-authors on publications and presentations.

**Work Plan:**

The proposed scope of work is scheduled for a one-year timeframe, beginning with notice to proceed from the Mountain Plains Consortium. Major project steps include the following:

|  |  |
| --- | --- |
| Task | Timeline |
| Collect safety data | Months 1-2 |
| Collect demography data | Months 1-2 |
| Collect transportation behavior data | Months 1-2 |
| Select 8 case study cities for safety in numbers and demography study | Months 3-4 |
| Select 2 case study cities for speed pilot study | Months 3-4 |
| Collect and evaluate speed data | Months 5-6 |
| Conduct built environment data collection | Months 7-8 |
| Clean, process, and geocode data | Months 8-9 |
| Analyze data | Months 9-10 |
| Incorporate lessons into transportation classes | Months 9-10 |
| Develop project website | Month 11 |
| Draft manuscripts and presentation materials | Months 11-12 |

**Project Cost:**

Total Project Costs: $293,920.00

MPC Funds Requested: $146,991.48

Matching Funds: $146,928.52

Source of Matching Funds: University of Colorado Denver

**TRB Keywords:**

Road safety, bicycling, safety in numbers, street networks, livability, active transportation

**References:**

Ahangari, Hamed, Jason Outlaw, Carol Atkinson-Palombo, and Norman W. Garrick. 2014. An investigation into the impact of fluctuations in gasoline prices and macroeconomic conditions on road safety in developed countries In *Transportation Reserach Board Annual Meeting*. Washington, D.C.

City of Portland Bureau of Transportation. 2011. Fifth Transportation Safety Summit. Portland, OR.

Cotti, Chad D., and Nathan Tefft. 2011. "Decomposing the Relationship between Macroeconomic Conditions and Fatal Car Crashes during the Great Recession: Alcohol- and Non-Alcohol-Related Accidents." *The B.E. Journal of Economic Analysis & Policy* no. 11 (1 (Tpocis)):1-22.

Council, U.S. Green Building. 2009. LEED for Neighborhood Development. Washington, D.C.

Donohue, Pete. 2013. Mayor Bloomberg's aggressive traffic policies have caused massive drop in traffic deaths. <http://www.nydailynews.com/news/politics/bloomberg-overseen-huge-drop-traffic-deaths-article-1.1552588>.

Ekman, Lars. 2006. On the Treatment of Flow in Traffic Safety Analysis - a non parametric approach applied on vulnerable road users. Lund, Sweden: Lund Institute of Technology.

Ewing, Reid. 1996. *Best Development Practices: Doing the Right Thing and Making Money at the Same Time*. Washington, D.C.: APA Planners Press.

Ewing, Reid, Tom Schmid, Richard Killingsworth, Amy Zlot, and Stephen Raudenbush. 2003. "Relationship Between Urban Sprawl and Physical Activity, Obesity, and Morbidity." *American Journal of Health Promotion* no. 18 (1).

FHWA. 2013. *Traffic Volume Trends*. US DOT 2013 [cited September 25 2013]. Available from https://[www.fhwa.dot.gov/policyinformation/travel\_monitoring/tvt.cfm](http://www.fhwa.dot.gov/policyinformation/travel_monitoring/tvt.cfm).

Foxx, Anthony. 2014. Remarks at the 93rd Annual Transportation Research Board Chairman’s Luncheon. Washington, D.C.: U.S. Department of Transportation.

Handy, S., R. Paterson, and K. Butler. 2003. Planning for Street Connectivity: Getting from Here to There. In *Planning Advisory Service Report 515*: American Planning Association.

Healy, Michael. 2001. "Multilevel Data and Their Analysis." In *Multilevel Modelling of Health Statistics*, edited by A.H. Leyland and H. Goldstein. New York: John Wiley and Sons, Inc.

Jacobsen, Peter L. 2003. "Safety in numbers: more walkers and bicyclists, safety walking and bicycling." *Injury Prevention* (9):205-209.

Jensen, Niels. 2002. Cycle Policy 2002 - 2012. Copenhagen: City of Copenhagen Roads and Parks Department.

Kenworthy, Jeffrey, and Felix Laube. 2000. Millennium Cities Database for Sustainable Transport. Institute for Sustainability and Technology Policy, distributed by the International Union of Public Transport.

Litman, Todd. 2005. *Roadway Connectivity: Creating More Connected Roadway and Pathway Networks* 2005 [cited October 25 2005]. Available from <http://www.vtpi.org/tdm/tdm116.htm>.

Litman, Todd. 2009. Evaluating Public Transit Benefits and Costs. Victoria, B.C.: Victoria Transport Policy Institute.

Litman, Todd. 2013. Safer Than You Think! Revising the Transit Safety Narrative Victoria, BC: Victoria Transport Policy Institute

Mapes, Jeff. 2009. *Pedaling Revolution: How Cyclists Are Changing American Cities*. Corvallis, OR: Oregon State University.

Marshall, Stephen. 2005. *Streets & Patterns*. New York: Spon Press.

Marshall, Wesley, and Norman Garrick. 2011. "Evidence on Why Bike-Friendly Cities are Safer for all Road Users." *Journal of Environmental Practice* no. 13 (1):16-27.

Marshall, Wesley, and Norman Garrick. 2012. "Community Design & How Much We Drive." *The Journal of Transport & Land Use* no. 5 (2):5-12.

Miller, Stephen. 2013. Census: NYC Bike Commute Mode-Share Hits 1 Percent Threshold. <http://www.streetsblog.org/2013/09/23/census-nyc-crosses-1-threshold-for-regular-bike-only-commuters/>.

National Bicycle Dealers Association. 2012. A Look at the Bicycle Industry’s Vital Statistics.

New York City DOT. 2014. *Past Bicycle Projexts* 2013 [cited January 20 2014]. Available from <http://www.nyc.gov/html/dot/html/bicyclists/past-bike-projects.shtml>.

Nordback, Krista, and Wesley Marshall. 2010. Improving Bicycle Safety with More Bikers: An Intersection-Level Study. In *T&DI / ASCE Green Streets & Highways Conference*. Denver, CO.

Nordback, Krista, Wesley E. Marshall, and Bruce Janson. 2013. Bicyclist Safety Performance Functions for a U.S. City. . Paper read at Transportation Reserach Board Annual Meeting, at Washington, D.C.

OECD. 2011. Quality of Life: Transport. In *OECD Factbook*. Paris: Organisation for Economic Cooperation and Development.

OECD, and International Transport Forum. 2013. Cycling, Health and Safety. OECD Publlishing: Organization for Economic Cooperation and Development (

Politifact.com. 2011. Bus association head says buses safest mode of commercial transportation <http://www.politifact.com/virginia/statements/2011/jun/11/peter-pantuso/bus-association-head-says-buses-safest-mode-commer>.

Pucher, John, and Ralph Bueler. 2008. "Cycling for Everyone: Lessons from Europe." *Transportation Research Record* no. 2074:58-65.

Pucher, John, and Lewis Dijkstra. 2003. "Promoting Safe Walking and Cycling to Improve Public Health: Lessons From The Netherlands and Germany." *American Journal of Public Health* no. 93 (9):1509-1516.

Snyder, Tanya. 2013. Census: American Bike Commuting Up Nine Percent in 2012. <http://dc.streetsblog.org/2013/09/19/census-american-bike-commuting-up-nine-percent-in-2012/>.

Snyder, Tanya. 2014. *Secretary Foxx Pledges to Make Bike/Ped Safety a Priority*. StreetsBlog.org 2014 [cited January 20 2014]. Available from <http://dc.streetsblog.org/2014/01/15/sec-foxx-pledges-to-make-bikeped-safety-a-priority/>.

U.S. Census Bureau. 2013. American FactFinder. edited by D.C. Washington.