TRANSPORTATION RESEARCH SYNTHESIS

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Quantifying the Economic Impact of Bicycling: A Literature Review with Implications for Minnesota

Introduction

This document responds to the Minnesota Department of Transportation's Transportation Research Synthesis (TRS) request, May 2013, related to biking and its economic impact. The TRS instructed the team to:

- Compile previous efforts that quantify the economic benefits of bicycling
- Respond to the sectors and benefits outlined in the TRS request (health, employment, recreation, transportation, quality of life, and tourism), and identify methodologies in existing literature to quantify the described benefits
- Pay special attention to work completed in Minnesota and identify areas where findings of economic impact are robust and areas where more work is necessary to understand the economic impact of bicycling in Minnesota

The remainder of this document and its attachments present a comprehensive summary of the findings related to this request.

Summary

Findings:

More than 80 publications were reviewed, including published academic research, non-academic articles, and published governmental reports. This report provides a complete compilation of reviewed works (attached matrix of studies, in MS Excel format), and a summary of key studies organized by each sector in the TRS request. Based on this review, eight findings emerge:

Finding #1: Accurate counting, tracking, and categorizing bicycle usage is foundational to understanding economic impacts related to bicycling

Finding #2: Input-Output models (IMPLAN, REMI, REDYN) are the primary tools used to calculate economic impacts connected to industry, tourism, recreation, and facilities.

Finding #3: The benefits of physical activity related to health are well established, but additional work can be done in Minnesota to understand the specific ways bicycling is currently integrated into the physical activity of residents.

Finding #4: Capturing information about consumer spending and sponsor investments related to bicycle races, tours, and events is an important component of bicycling's economic impact.

Finding #5: Similar studies have adopted a framework for categorizing and isolating bicycle related benefits

Finding #6: Construction cost data for bicycle facility projects at the state, regional, and local level are a valuable information source easily used to calculate economic impacts using input -output models (IMPLAN, REMI, REDYN)

Finding #7: Research already completed in Minnesota is selective and on a whole doesn't provide a comprehensive understanding of all impacts related to bicycling

Finding #8: Accurate estimates of bicycling impacts will avoid double counting, extrapolating the results of customized non-Minnesota economic models to Minnesota, and comingling data related to users and non-users, as well as data related to visitors and non-visitors.

Suggested Next Steps:

This report also suggests the following next steps for conducting research to quantify the economic impacts of bicycling in Minnesota.

1.) Assess the impact of bicycling related industries and events in Minnesota by;

   a. Assembling data about the number, overall employment, revenue, and supply chain for bicycling related firms (retailers, wholesalers, manufacturers, and general merchandise stores) in Minnesota. This data could be obtained using questionnaires, focus groups, or key informant interviews. Arizona DOT's work is an excellent template to follow (McClure, Working Paper #2, 2012): http://azdot.gov/mpd/systems_planning/BicyclingAZ.asp

   b. Assembling data about bicycle races, tours, and events in Minnesota. This data should include: the number of events; the amount of visitor spending; the attendance; and visitor profiles. Again, Arizona DOT's work is a useful starting place for related database templates.

   c. Analyzing the above mentioned data using an input-output model. IMPLAN is likely the most cost effective tool.

2.) Update the 2009 Recreational Trail Study (Venegas, 2009) to learn more about the current state of trail use as it related to bicycling.

3.) Gather bicycle facility construction cost data from local, regional, and state projects. Analyze this data using an input-output model

4.) Collect primary data, on a statewide basis, related specifically to bicycle usage, health characteristics, bicycling perceptions, and the ways bicycling contributes to users lives. Several methods are mentioned in Finding #2 & #3 (above). Analyze the health data using the Health Economic Assessment Tool (HEAT) tool.

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Quantifying the Economic Impact of Bicycling: A Literature Review with Implications for Minnesota

Written in response to a Minnesota Department of Transportation Research Synthesis Request

Presented/Authored by Neil Linscheid, Baishali Bakshi, & Brigid Tuck

Quantifying the Economic Impact of Bicycling: A Literature Review with Implications for Minnesota

June 26, 2013

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The remainder of this document and its attachments present a comprehensive summary of the findings related to this request.

OVERVIEW

The literature reviewed is categorized in the following three ways:

1. comprehensive analysis of the economic and social impacts of bicycling done at a state or municipal level (including Arizona, Wisconsin, and Iowa),
2. benefit specific analysis on a general scale such as the overall health benefits related to bicycling, the general transportation benefits related to bicycling, or the benefits of tourism related to bicycling.
3. case studies to determine the impact of place specific investments, events, or policies (trails, races, facilities).

An initial, comprehensive, but dated, analysis of the economic impact of biking in Minnesota offers an excellent foundation for this review (Barnes 2004). Barnes divides the economic benefits of biking into two primary categories: 1.) user benefits and 2.) general benefits. Each category is further subdivided to differentiate benefits. Barnes provides rough estimates on the benefits and costs of each subcategory. Based on these, he argues the health and industry related benefits are likely the largest, most important benefits. In contrast, he also argues that following represent minor benefits; A.) Lower transportation costs for bicyclists, B.) Reduced government and infrastructure costs, and C.) Reduced problems associated with automobile use. Applying additional rigor and utilizing this framework may be an attractive way to ensure that all of the impacts related to bicycling are captured.

Other statewide studies and literature reviews have approached the challenge of categorizing bicycling impacts slightly differently, based on project needs. In Wisconsin, benefits and costs were organized by health and economic terms (Grabow, 2010). Iowa followed a similar framework, but innovated on the data sources and collection methods by obtaining health data from Blue Cross Blue Shield (reference, year). Work done in Colorado (Argys & Mocan, 2000) and Portland (Wiegand, 2008) distinguishes between studies of economic impact and those of economic value. Economic impacts

defined as industry-related whereas tourism and economic value are measured through property values.

The analysis performed in Arizona should be implemented as a template in Minnesota because; it matches closely with the intended scope of the TRS request, it provides a clear literature review, its accompanying appendices contain sample databases and many of the needed tools necessary to administer an industry focused questionnaire and focus group (reference, date). In addition, it provides three categories from which to view impacts: 1.) Infrastructure orientation, 2.) user orientation, and 3.) industry orientation. MnDOT might adopt a similar structure for its analysis and any requests for work to assess the impact of bicycling in Minnesota.

KEY FINDINGS

More than 80 publications were reviewed, including published academic research, non-academic articles, and published governmental reports. This report provides a complete compilation of reviewed works (attached matrix of studies, in MS Excel format), and a summary of key studies organized by each sector in the TRS request. Based on this review, eight findings emerge.

Finding #1: Accurate counting, tracking, and categorizing bicycle usage is foundational to understanding economic impacts related to bicycling

- The Pedestrian and Bicycling Survey (Forsyth, Agrawal, & Krizek, 2012) is a reliable and low cost method for understanding who, how often, and why people are bicycling.
- New technologies such as passive signal (collecting information from mobile devices), active route and behavior logging applications (using social media & other websites to track user data), and passive video (using software to process video) and are being tested to improve bicycle usage tracking. These technologies may be provide new levels of accuracy previously unavailable. (Transportation Research Board of the National Academies 2012, p. 8-9,)

Finding #2: Input-Output models (IMPLAN, REMI, REDYN) are the primary tools used to calculate economic impacts connected to industry, tourism, recreation, and facilities.

- Estimates of economic impacts are most commonly calculated using in input-output tools such as IMPLAN, REMI, or REDYN (McClure, Working Paper #2, 2012), (Argys and Mocan, 2000), (Lankford et al., 2011)
- Accurate inventories of all bicycle related firms (specialty retail, wholesale, manufacturing, general merchandise) in Minnesota which include information about revenue and employment will be critical to the development of accurate input-output models (McClure, Working Paper #2, 2012), (Argys and Mocan, 2000), (Lankford et al., 2011). This type of inventory may exist and may be made available to researchers through partnerships with bicycle related firms.
- The questionnaire and methods implemented by Arizona DOT are helpful as a template for assessing the bicycling industry in Minnesota. This work includes key informant interviews, business questionnaires, development of a business database, and an event and touring database (McClure, Working Paper #2, 2012)

Finding #3: The benefits of physical activity related to health are well established, but additional work can be done in Minnesota to understand the specific ways bicycling is currently integrated into the physical activity of residents.

- The International Physical Activity Questionnaire (IPAQ) is a rigorous and in-depth questionnaire which has been utilized for understand bicycling in relation to physical activity. This tool was utilized in 2004 in the Twin Cities (Forsyth and Oakes, 2013).
- The results of the 2012 Active Living Minnesota Physical Activity Survey provide valuable information related to bicycling in the context of other physical activity in Minnesota (ALMPAS, 2012). Questions 11, 13, and 16 refer specifically to bicycling.
- The Health Economic Assessment Tool (HEAT) is an internationally utilized tool used for estimating the economic benefits of bicycling as they relate to health (Rutter et al. 2013).
- The health benefits related to physical activity are well established (DHHS, 2008)

Finding #4: Capturing information about consumer spending and sponsor investments related to bicycle races, tours, and events is an important component of bicycling's economic impact.

- Consumer spending data related to recreational trail use in Minnesota has already been collected (Venegas, 2009). This work if replicated could also include an effort to assess bicycle races, tours, and other events.
- Regional trail impact studies have been conducted and provide sample survey tools and methods which can be replicated in Minnesota (Bowker, Bergstrom, and Gill, 2007; CDC Policy Analysis, 2012; Kelly, 2009)
- Past efforts to calculate the impact of bicycle races, tours, and other bicycling related events can be used as a guide for future researchers (Kashian and Kasper, 2010).

Finding #5: Similar studies have adopted a framework for categorizing and isolating bicycle related benefits

- A basic analysis and comprehensive framework have already been proposed and used in Minnesota. This framework separates the facility benefits from the general benefits. (Barnes, 2004)
- Arizona DOT utilizes three orientations in which to organize benefits;1.) User orientation, 2.) Industry orientation, 3.) Infrastructure orientation. (McClure, Working Paper #1, 2012)
- Both the Arizona DOT and Barnes frameworks offer a comprehensive way to organize information and conduct research effectively. Further, other frames exist (Krizek, 2007) & (Weigand, 2008), but the two referenced above are most applicable to Minnesota.
- Researcher Kevin Krizek suggests that benefits should meet five criteria "They need to be 1.) measured on a municipal or regional scale; 2.) central to assisting decision makes about transportation/urban planning; 3.) estimable via available existing data or other survey means; 4.) converted to measures comparable to one another; 5.) be measuring benefits for both users and non-users. (Krizek, 2007, p.231)

Finding #6: Construction cost data for bicycle facility projects at the state, regional, and local level are a valuable information source easily used to calculate economic impacts using input -output models (IMPLAN, REMI, REDYN)

- Utilizing data related to construction costs and the ways in which those costs where distributed between inputs (labor, materials, land) is a direct and reliable way to construct input-output models related to bicycling and pedestrian facility construction (Garrett-Peltier, 2011).
- Construction & project related data may already be available at the state, regional, and municipal level.

Finding #7: Research already completed in Minnesota is selective and on a whole doesn't provide a comprehensive understanding of all impacts related to bicycling

- Minnesota specific research has been done on:
    - The use of non-motorized infrastructure (Hankey et al, 2012).
    - Bicycle Share programs (Schoner, Harrison, Wang, Lindsey, 2012).
    - The relationship between facility investment and commuter mode (Krizek, Barnes, Thompson, 2009) & (Cleaveland and Douma, 2009)
    - Relationship between cycling, health, and the built environment (Forsyth & Oakes, 2013)
    - Estimates of the benefits of bicycling (Barnes, 2004)
    - Trail usage and consumer spending estimates (Kelly, 2009) & (Venegas, 2009)
- More research needs to be conducted to better understand:
    - Welfare analysis in terms of how biking benefits are distributed between rural/urban areas, demographic strata or economic strata.
    - Bicycling as an industry in Minnesota
    - Retail sales of bicycle related products in general merchandise stores and sporting goods stores
    - Levels and nature of local and regional bicycle facility investments and impacts
    - The economic activity occurring as a result of Minnesota bicycle races, tours, and bicycling related events

Finding #8: Accurate estimates of bicycling impacts will avoid double counting, extrapolating the results of customized non-Minnesota economic models to Minnesota, and comingling data related to users and non-users, as well as data related to visitors and non-visitors.

- Avoid predicting figures on Minnesota bicycle industry based on reports on the bicycle industry in other cities, regions or states.

- Keep in mind the limitations of cross-sectional studies in linking bicycle infrastructure and biking.
- Keep in mind that input-output models are region specific.
- Avoid imputing impacts of bicycle tourism in other states to Minnesota. Bicycle tourism in Minnesota and use of bicycle facilities need to be considered with reference to factors not discussed well in the literature, for example climate and weather.
- Avoid estimating the economic benefits and costs related to health without primary data collection on actual cycling and physical health behaviors.
- Consider separating user from non-user impacts (Barnes, 2004)
- Determine the amount of tourist spending attributable solely to bicycling with careful attention paid to the definition of a tourist. (Crompton, 2001)

SUGGESTED NEXT STEPS TO ASSESS THE ECONOMIC IMPACT OF BICYCLING IN MINNESOTA

1.) Assess the impact of bicycling related industries and events in Minnesota by;

   a. Assembling data about the number, overall employment, revenue, and supply chain for bicycling related firms (retailers, wholesalers, manufacturers, and general merchandise stores) in Minnesota. This data could be obtained using questionnaires, focus groups, or key informant interviews. Arizona DOT's work is an excellent template to follow (McClure, Working Paper #2, 2012): http://azdot.gov/mpd/systems_planning/BicyclingAZ.asp

   b. Assembling data about bicycle races, tours, and events in Minnesota. This data should include: the number of events; the amount of visitor spending; the attendance; and visitor profiles. Again, Arizona DOT's work is a useful starting place for related database templates.

   c. Analyzing the above mentioned data using an input-output model. IMPLAN is likely the most cost effective tool.

2.) Update the 2009 Recreational Trail Study (Venegas, 2009) to learn more about the current state of trail use as it related to bicycling.

3.) Gather bicycle facility construction cost data from local, regional, and state projects. Analyze this data using an input-output model

4.) Collect primary data, on a statewide basis, related specifically to bicycle usage, health characteristics, bicycling perceptions, and the ways bicycling contributes to users lives. Several methods are mentioned in Finding #2 & #3 (above). Analyze the health data using the Health Economic Assessment Tool (HEAT) tool.

SUMMARY OF RESEARCH RELATED TO EACH SECTOR IDENTIFIED IN THE TRANSPORTATION RESEARCH SYNTHESIS (TRS) REQUEST

A comprehensive approach to analyzing the economic impacts of bicycling in Minnesota allows researchers to identify the benefits related to each sector in turn and draw distinctions more readily among them. To develop in-depth knowledge, the Transportation Research Synthesis Request identified several sectors for investigation and analysis. This section and subsequent subsections summarizes each sector by highlighting the most relevant and Minnesota applicable studies.

STATE STUDIES AND LITERATURE REVIEWS

Several states have worked to understand economic impacts related to bicycling. Past efforts have been similar in many respects. Most efforts focus on understanding the amount of cycling activity taking place (commuters, races, tourism, etc.). Data related to cycling activity, facility construction, and tourism activities are then used as inputs in economic models (input-output models and cost-benefit models). The highest quality efforts gather data via primary data collection methods such as surveys and interviews. Data about the bicycling industry, as described in the next section, is challenging to aggregate. The solution is most often to conduct firm surveys or interviews. In general, the state level estimates related to industry and tourism impacts are reliable and consistent. However, health impacts are commonly linked to these studies and those are less transparent or reliable.

- Argys, L. M., & Mocan., H. N. (2000). Bicycling and Walking in Colorado: Economic Impact and Household Survey Results. Prepared for the Colorado Department of Transportation, Bicycle/Pedestrian Program. University of Colorado at Denver, Center for Research on Economic and Social Policy. doi:10.1037/e497092006-010

  Highlights: This study is often cited by others working on state level economic impact efforts related to bicycling. The authors conducted household surveys to determine the spending related to bicycling in Colorado. The results of those surveys where then used in an IMPLAN input-output model to estimate the direct, indirect, and induced impacts to the state economy.

- Bicycle Federation of Wisconsin, & Wisconsin Department Of Transportation. (2006). *The Economic Impact of Bicycling in Wisconsin*. Prepared for the Governor's Bicycling Coordinating Council.

  Highlights: This study analyzed the impact of bicycling in Wisconsin through the lens of industry and tourism. Using a REMI input-output model the authors calculated the total impact of bicycling in Wisconsin. Bicycling as an industry included manufacturing, retailing, wholesale and service, and other firms. Tourism as an industry included trails, mountain biking, single day tours, multiday tours, and races.

- Coalition. Sustainable Tourism and Environmental Program, University of Northern Iowa, Cedar Falls, Iowa. http://www.uni.edu/step/reports/economic_health_benefits_of_bicycling.pdf

  Highlights: This study is similar to the work done in Wisconsin. It analyzes commuter and recreational cyclists, bicycle establishments, bicycle organizations, and health benefits using a series of three questionnaires distributed in 2011. It is notable for its inclusion of bicycle related

organizations and the calculation of costs related to bicycling. This study offers a valuable method for understanding the characteristics of bicycle retail establishments. The methods related to health impacts are not as rigorous (see entry in health section).

- Lankford, J., Lankford, S., Grybovych, O., Bowles, B., Fleming, K., Fuller, K., Lankford, J., & Printz, J. (2011). Economic and Health Benefits of Bicycling in Iowa. Prepared for the Iowa Bicycle Coalition. Sustainable Tourism and Environmental Program, University of Northern Iowa, Cedar Falls, Iowa. http://www.uni.edu/step/reports/economic_health_benefits_of_bicycling.pdf

  Highlights: This study is also similar to the work done in Wisconsin. It analyzes the commuter and recreational cyclists, bicycle establishments, bicycle organizations, and health benefits using a series of three questionnaires distributed in 2011. It is notable for its inclusion of bicycle related organizations and the calculation of related costs. This study offers a valuable method for understanding the characteristics of bicycle retail establishments. The methods related to health impacts are not as impressive (see entry in health section).

- Mc Clure Consulting LLC et al., (2012). Economic Impact of Bicycling in Arizona, Working paper #1, 1-61. & Working paper #2.

  Highlights: Paper #1 is a comprehensive review of literature on economic impact of bicycle tourism in Arizona. It is also part of a broader study aimed at estimating the economic impact of bicycling in Arizona, commissioned by the ADOT, similar to our project.

  Paper #2 is a highly relevant review and refinement of the recommended methods for analyzing the economic impact of bicycling in Arizona. It documents the data needs and availability, provides sample surveys and questionnaires, and recommends an input-output analysis tool called REDYN. This study is a useful guide to conducting an industry level analysis and provides important methodological guidance.

- Noland, R. B., Deka, D., & Walia, R. (2011). A Statewide Analysis of Bicycling in New Jersey. *International Journal of Sustainable Transportation, 5*(5), 251–269. doi:10.1080/15568318.2010.501482

  Highlights: This paper examines biking behavior in New Jersey, a bicycle friendly state like Minnesota; and finds through statewide survey and rigorous econometric analysis that demographic, socioeconomic and place-based factors are important determinants of biking. Interesting finding: Employed, affluent, white households with children and 3 or more vehicles are more likely to bicycle.

In addition, several other literature reviews on topics contained in the TRS request have been conducted. Below is a selection of other literature reviews which will be helpful to researchers as they conduct a study on the economic impact of bicycling in Minnesota.

- Litman, T. (2013). Evaluating Non-Motorized Transportation Benefits and Costs. *Victoria Transport Policy Institute*, 134–140.

Highlights: This is a literature review with a focus on advocating for increased investments in non-motorized transportation. It provides a useful summary of the methods commonly used to monetize the costs and benefits of human powered transportation which includes bicycling. It provides summaries and suggestions for assessing the costs and benefits of non-motorized travel. This work concludes "that non-motorized travel provides significant benefits."

- Weigand, L., & Ph, D. (2008). A Review of Literature : The Economic Benefits of Bicycling A Review of Literature : The Economic Benefits of Bicycling (pp. CUS–CTS–08–03).

  Highlights: This is a summary and literature review of the work that has been done on the economic benefits of bicycling. It documents the work done to understand the impacts of industry and tourism, and bicycle facilities. It categorizes the work done on bicycling into three areas: 1.) Traditional economic analysis focusing on the sector 2.) Impact studies related to trails or facilities. 3.) Documentation of economic value using cost benefit or return on investment methods.

EMPLOYMENT AND BICYCLING AS AN INDUSTRY

As of 2013, knowledge on the employment impacts related to bicycling is primarily found in the results from other statewide studies (Wisconsin, Colorado, Iowa, and Maine). The process for estimating employment effects is generally done through the use of an input-output model. A variety of input-output models have been used; IMPLAN, REMI, REDYN. Estimation of employment effects is linked to business to business purchasing, consumer spending, and visitor spending. The critical piece to the use of any input-output model is credible and reliable data about the number of firms and their production functions, visitor data, and consumer spending data.

Industry analysis is often done using aggregated firm data organized by the North American Industrial Classification System Codes (NAICS). The NAICS classification for bicycle parts and motorcycle parts manufacturing is 336991. IBIS Industry Reports estimates the bicycling manufacturing industry output at $872 million in 2013. Much of this industry has shifted to lower cost overseas production. According to the US Census Minnesota 2010 County Business Patterns, Minnesota is home to 7 firms, with 73 employees, and $3.3 million in annual payroll, in the 336991 NAICS class. The most recent IMPLAN data shows 90 jobs, $59.3 million in output, $3.1 in labor income. Bicycleshops.us lists 75 bicycle specific retail establishments in Minnesota. There is very little confidence (several large manufactures are not represented here, but a more accurate data source for additional information in unavailable) in these initial data. Gathering additional data about the bicycling industry is an important step for any economic impact analysis project.

The amount of retail purchases made in general merchandise and sporting goods stores is an important component of understanding the bicycling industry. Gathering this data is challenging. This data is not itemized by the questionnaires required by the MN Department of Revenue. Challenges aside, it will be useful for any study to explore the share of retail bicycle sales which occur online, at specialty stores, at general merchandise stores, and at sporting goods stores. Minnesota based bicycle manufacturing firms may be a helpful partner for gathering this information. Additionally, the National Bicycle Retailers Association, a bicycle retailer industry group, conducts an annual study of bicycle retail firms in the United States. This study is available for purchase.

One additional study is worth noting because of its unique approach and specific goal of estimating employment effects of infrastructure investments:

- Garrett-Peltier, H. (2011). Pedestrian and Bicycle Infrastructure: A National Study of Employment Impacts. Amherst, MA: Political Economy Research Institute.

  Highlights: This study is the only of its kind to take attempt to estimate the employment effects of bicycle facility construction. Using project cost data from 11 states the authors create an input-output model to estimate the employment effect for each $1 million spent on pedestrian and cycling projects. They estimate “For each $1 million, the cycling projects in this study create a total of 11.4 jobs within the state where the project is located.”

There still several open questions related to the bicycling industry in Minnesota. For instance, what level of bicycle related sales are attributed to general merchandise stores in Minnesota and what is an effective method for estimation? Would general merchandise retailers readily provide this information?

Future studies seeking to estimate the employment effects should follow the examples set forth by Arizona DOT in particular. Efforts will likely include interviews and questionnaires targeted at retailers, manufacturers, and service providers. An important place to start will be a reliable and complete inventory of bicycle related firms in the state. Arizona DOT has also made their work easy to follow and transparent. Several useful pieces of information including project plans, meeting notes, presentations, sample questionnaires, and overall study design information can be found at the following website: http://azdot.gov/mpd/systems_planning/BicyclingAZ.asp .

HEALTH

The key articles reviewed in connection with bicycling impacts and health were selected primarily based on the definition of health in this project: decreased short term health care costs resulting from higher physical activity and long-term societal savings due to increased physical fitness among workers and health care consumers. They were chosen based on their fit in this project, rigor of analysis, whether or not the article was peer-reviewed, and the compatibility of study location with Minnesota.

Health surveys, primarily directed at cyclists, represent the most commonly implemented approach for measuring the link between physical health and cycling. Placing an economic value on the link is often accomplished by connecting the costs of physical inactivity to the incidence of disease and then attributing the reduction of disease prevalence to the benefits of bicycling. The development of the Health Economic Assessment Tool (HEAT) has advanced the sophistication of analysis.

Results of health-related bicycling studies demonstrate that cycling consistently leads to higher benefits than costs. However, the degree and magnitude of these impacts are not consistent. A lack of transparency, coupled with that inconsistency, make it challenging to compare efforts and results (Cavill, 2008).

Primary data about bicycling and physical health is a critical component of an accurate estimate of the benefits and costs of bicycling.

- Cavill, N., Kahlmeier, S., Rutter, H., Racioppi, F., & Oja, P. (2008). Economic analyses of transport infrastructure and policies including health effects related to cycling and walking: A systematic review. *Transport Policy*, *15*(5), 291–304. doi:10.1016/j.tranpol.2008.11.001

  Highlights. This paper uses a systematic review methodology to review studies and assigns a value to each. The review found wide variation in cost benefit approaches. The authors highlight the importance of and lack of transparency as it relates to the methods for calculating costs and benefits and the lack of transparency in methods. The major issue raised is the "relationship between observed cycling or walking and total physical activity." This study offers a useful comparison of studies and their quality.

- Forsyth, A., & Oakes, J. M. (2013). Cycling, the Built Environment, and Health: Results of a Midwestern Study. *International Journal of Sustainable Transportation*, (May), 130305081302008. doi:10.1080/15568318.2012.725801

  Highlights: Critical to any attempt at quantifying the economic benefits of cycling through changes in health is the assumption that health will be impacted as a result of increased cycling. Key findings of this study include identifying and defining "occasional cyclists" those who own cycles and have cycled in past two years, but had not cycled in past week. The research relies on data from the Twin Cities Walking Study conducted in 2004 involving 703 participants. Participants wore accelerometer and kept a travel diary for four two month periods. Their height, weight, and BMI were measured.. Participants also completed the International Physical Activity Questionnaire. The study concludes: "cycling doesn't necessarily increase physical activity if it substitutes for other types of activity such as walking".

- Garrard, J., Rissel, C., & Bauman, A. (2012). Health benefits of cycling. City Cycling, 31.

Highlights: This chapter from City Cycling focuses on the health benefits related to cycling. The authors provide a useful categorization of the health benefits related to cycling; 1) epidemiological 2) psychosocial benefits (mental health and well-being, treatment and prevention of mental health, cognitive functioning), 3) emotional well-being, 4) social health benefits, 5) reduction of health inequalities, 6) reduced motor vehicle use, 7) improved air quality, 8) reduced noise pollution, 9) greenhouse gas emissions and climate change, and 10) economic benefits. This study reviews areas where others have studied the relationship between health and cycling. However, it fails to offer any useful criticism or direction. For instance, although this paper accurately describes the BCR's from the above mentioned Cavill Et al. study, it fails to mention the more important finding that few studies were high quality and even among high quality studies there were serious issues related method transparency and connections to morbidity.

- Gotschi, T. (2011). Costs and benefits of bicycling investments in Portland, Oregon. *Journal of Physical Activity & Health*, *8 Suppl 1*(Suppl 1), S49–58. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/21350262

  Highlights: This study compares the results of two methods for assessing the monetized health benefits of bicycling. The health care cost savings method and the reduction in mortality (HEAT) are both used to estimate the present and future value of bicycle investments in Portland. The authors conclude "investments in bicycling infrastructure and promo- tion, yielding benefit-cost ratios between 3.8 and 1.2 to 1. Accounting for lives saved from a reduction in mortality using value of statistical life, as is commonly done for transportation projects, dramatically increases the benefits-cost ratio (p.S56)".

- Grabow, M. L., Hahn, M., & Whited, M. (2010). Valuing bicycling ' s economic and health impacts in Wisconsin. *The Nelson Institute for Environmental Studies Center for Sustainability and the Global Environment.*

  Highlights: This study (also mentioned elsewhere in this review) has a specific focus on estimating bicycling's impact on health. Researchers estimate the health impacts of bicycling by looking at the substitution of short car trips. Increases in physical activity were then input into the World Health Organizations Comparative Risk Assessment tool. However, the specific methods to estimate costs per case are unclear. The basic calculation is to estimate the prevalence of breast cancer, colorectal cancer, stroke, heart disease, and diabetes in a region.

- Grabow, M. L., Spak, S. N., Holloway, T., Stone, B., Mednick, A. C., & Patz, J. a. (2012). Air quality and exercise-related health benefits from reduced car travel in the midwestern United States. *Environmental Health Perspectives*, *120*(1), 68–76. doi:10.1289/ehp.1103440

  Highlights: This study uses the Health Economic Assessment Tool (HEAT) as a primary tool to estimate the health effects of replacing short automobile trips with bicycle transportation. It assumes large substitution for car travel is possible (20%) for short trips. The authors conclude that "Making 50% of short trips by bicycle would yield savings of approximately $3.8 billion/year from avoided mortality and reduced health care costs (95% CI: $2.7 billion, $5.0 billion]. (p. 73).

- Lankford, J., Lankford, S., Grybovych, O., Bowles, B., Fleming, K., Fuller, K., Lankford, J., & Printz, J. (2011). Economic and Health Benefits of Bicycling in Iowa. Prepared for the Iowa Bike Coalition.

Sustainable Tourism and Environmental Program, University of Northern Iowa, Cedar Falls, Iowa. http://www.uni.edu/step/reports/economic_health_benefits_of_bicycling.pdf

Highlights: This study uses a similar method to the work done in Wisconsin by Grabow et al. (2010) to estimate the health benefits related to cycling. The study estimates the prevalence of disease, costs related to those diseases and the savings when the incidence is reduced due to biking. The notable difference in this study is the use of the Blue Cross Blue Shield treatment cost estimator to determine the cost for each disease by percentile (a notable improvement from the methods used in the Wisconsin study), however it is still reliant on the same fundamental assumptions.

- Oja, P., Titze, S., Bauman, a, De Geus, B., Krenn, P., Reger-Nash, B., & Kohlberger, T. (2011). Health benefits of cycling: a systematic review. *Scandinavian Journal of Medicine & Science in Sports*, *21*(4), 496–509. doi:10.1111/j.1600-0838.2011.01299.x

  Highlights: This paper was a systematic review of the health benefits of cycling. Sixteen studies met the inclusion criteria for this review. The review found strong evidence for fitness benefits, moderate evidence for cardiovascular risk factors, and inconclusive evidence on mortality, cancer risk, and obesity. Finally, it finds an inverse relationship for commuter cycling and all-cause mortality, cancer mortality, and cancer morbidity, in studies focused on populations of the middle-aged and elderly.

- Rutter, H., Cavill, N., Racioppi, F., Dinsdale, H., Oja, P., & Kahlmeier, S. (2013). Economic impact of reduced mortality due to increased cycling. *American Journal of Preventive Medicine*, *44*(1), 89–92. doi:10.1016/j.amepre.2012.09.053

  Highlights: This article describes a tool which the authors developed and implemented called the Health Economic Assessment Tool (HEAT) for bicycling and walking. The tool uses the value of a statistical life as the core component of the output. It was developed specifically to answer this question: "For a given volume of cycling within a defined population, what is the economic value of the health benefits?" This is the most widely used and academically rigorous approach to this question. This tool was also used in Grabow et al. 2012.

TRANSPORTATION

Summary: Research at the intersection of transportation, bicycling, and economics has focused in two areas. One area of research involves quantifying the economic benefits and costs of both non-motorized transportation and of infrastructure development to promote and support cycling. A second area of research delves into the role of infrastructure in influencing transportation choices. Further, researchers examining this topic are interested in the various ways in which bicycling counts can be obtained.

- Krizec, K.J., (2007). Estimating the Economic Benefits of Bicycling and Bicycle Facilities: an Interpretive Review and Proposed Methods, Book Chapter, 13, 219-248.

  Highlight: This is a valuable critical review on existing literature on economic benefits of bike facilities, points out the problems in such estimations and provides a tabulated comparison of studies.

- Litman, T. (2013). Evaluating Non-Motorized Transportation Benefits and Costs. *Victoria Transport Policy Institute*, 134–140.

  Highlights: This a literature review with a focus on advocating for increased investments in non-motorized transportation. It provides a useful summary of the methods commonly used to monetize the costs and benefits of human powered transportation which includes bicycling. It provides summaries and suggestions for assess in the costs and benefits of non-motorized travel. This work concludes "that non-motorized travel provides significant benefits.."

- Mc Clure Consulting LLC et al., (2012). Economic Impact of Bicycling in Arizona, Working paper #1, 1-61.

  Highlights: This study groups transportation-related benefits under the topic of "infrastructure orientation focus". The authors identify two primary components related to this focus: a.) "costs associated with the plan and design, operation and maintenance of cycling/pedestrian infrastructure and b.) direct benefits associated with the use of cycling infrastructure, identifying the full range of direct and indirect benefits to cyclists".

- Moudon, A. V., Lee, C., Cheadle, A. D., Collier, C. W., Johnson, D., Schmid, T. L., & Weather, R. D. (2005). Cycling and the built environment, a US perspective. *Transportation Research Part D: Transport and Environment*, *10*(3), 245–261. doi:10.1016/j.trd.2005.04.001

  Highlights: This is a highly cited article which develops a profile of cyclists and analyzes how the built environment effects perceived and actual conditions. There are several key findings: a.) presence of bicycle lanes, traffic speed and volume, slope, block size, and presence of parks are found insignificant b.) "a non-linear relationship is found between the odds of cycling and the perception of traffic problems and automobile-oriented facilities" c.) cycling "appears to be an individual choice that is independent from environmental support".

- J. Richard Kuzmyak and Jennifer Dill (2012), "Walking and Bicycling in the United States: The Who, What, Where, and Why," TR News 280, May-June; at http://onlinepubs.trb.org/onlinepubs/trnews/trnews280www.pdf.

  Highlights: This article is provides a current understanding of the techniques used to collect data related to bicycling. The authors describe new techniques which utilize GIS and other methods of tracking. Most helpful is the mention of the NCHRPP 07-19 project led by Paul Ryus to collect pedestrian and bicycle data (planned completion spring 2014). The key variables considered in this article were frequency of travel, travel distance, travel purpose, geographic location, influence of environment (natural and built), and attitudes and perceptions.

QUALITY OF LIFE

Cycling rates doubled between 1990 and 2000 in many United States cities, including Minneapolis. Cities with high growth have committed to efforts to increase bicycling infrastructure and safety. Recent MnDOT sponsored research focused on understanding quality of life from a citizens perspective (Schneider, Guo, & Schroeder, 2013) offers a unique definition of quality of life: "QOL is complex and transportation plays an important and consistent role in it across Minnesota; transportation is critical to QOL because it connects us to important destinations in aspects that matter most; and Minnesotans can readily identify what matters and how the state is performing within the breadth of transportation services. (p.1)"

Common methods used to research the role of bicycling in quality of life include surveys directed at an identified study population, e.g. bike tourists, commuters and bike-related businesses; literature reviews; economic impact models like IMPLAN, revealed preference methods like hedonic pricing for examining effect of bike paths on property values, regression analysis, and use of spatial (GIS) data on bike facilities.

- Flusche, D., (2012). Bicycling Means Business: The Economic Benefits of Bicycle Infrastructure, Policy review report by Advocacy Advance, 1-28.

  Highlights: 2009 MN study found bicycle-riders' spending accounted for $261 mn. in the MN GSP.

- Krizec, K.J., (2007). Estimating the Economic Benefits of Bicycling and Bicycle Facilities: an Interpretive Review and Proposed Methods, Book Chapter, 13, 219-248.

  Highlights: This is a valuable critical review on existing literature on economic benefits of bicycle facilities, points out the problems in such estimations and provides a tabulated comparison of studies.

- Meletiou, M. P., Lawrie, J.J., Cook, T.J. et al. (2005). Economic impact of investment in Bicycle facilities: Case study of North Carolina's northern outer banks. *Transportation Research Record*, 1939, 15-21.

  Highlights: The paper examines the value of bicycle infrastructure through the economic impact of bicycling tourists which fits very well with quality of life. It also involves a rigorous survey design and economic impact analysis and finds that bicycle facilities are an economically sound investment for Outer Banks, North Carolina.

- Schneider, I.E., Guo, T.; and Schroeder, S., (2013). Quality of life: Assessment for transportation performance measures, UMN Policy Analysis report, 1-161.

  Highlights: Examines the role of transportation measures in quality of life through focus groups and a mail survey for Minnesota. Survey resulted in 11 QOL measures important for transportation choices.

- Shafer, C.S.; Lee, B.K.; and Turner, S., (2000). A tale of three greenway trails: user perceptions related to quality of life, Landscape and Urban Planning, 49, 163-178.

  Highlights: This article reviews trends in cycling over 1980-2000 and includes comparisons at national (US and Canada) and city levels (9 cities including Chicago, Minneapolis, Portland and

Toronto) focusing on bicycling infrastructure, bicycle safety, and bicycle friendliness. It finds that cycling has gone up in both countries but the growth is concentrated in large cities, University towns and upscale neighborhoods that have substantially invested in bicycle facilities and bicycle safety.

RECREATION

Articles related to bicycling and recreation show that individuals primarily bicycle for recreation versus transportation. Individual attitudes choices like residential sorting and characteristics such as (bicycle comfort) play a critical role in determining the balance between transportation and recreation. Commonly applied methods for research related to recreation and cycling include revealed preference approaches such as travel cost method, binary and multinomial logit models, regression analysis and GIS data.

Articles in this sector were found primarily based on the definition of recreation in this project: *Trip expenditures and equipment purchases made by Minnesotans who bike recreationally*

- Grabow, M.; Hahn, M.; and Whited, M. (2010). Estimating the economic impact of bicycling recreation, tourism, and induced health benefits in Wisconsin, Policy analysis report by Univ. of Wisconsin, Madison, 1-42.

  Highlights: This paper estimates economic impact of bicycling recreation, tourism, and induced health benefits in MN's neighboring state, Wisconsin, using statewide surveys and the economic impact model IMPLAN and finds a significant annual economic impact of $924 mn.

- Industry report by Outdoor Industry Foundation, (2006). The Active Outdoor Recreation Economy: A $730 Billion Annual Contribution to the U.S., 1-9.

  Highlights: This industry report provides statistics on the economic impact of biking, nationally and regionally through surveys and imputed IMPLAN multipliers and finds that the West north central region (including MN) is 3rd in number of bicyclers but accounts for about 2% of total revenue (133 bn) and 3% of jobs (1.1 mn) from bicycling in US implying scope for growth.

- Krizec, K.J.; Barnes, G.; and Thompson, K. (2009). Analyzing the Effect of Bicycle Facilities on Commute Mode Share over Time, Journal of Urban Planning and Development, 135(2), 66-73.

  Highlights: This paper examines changes in biking between 1990 and 2000 and their relation with biking facilities, in the Twin Cities, MN. It uses appropriate surveys, spatial data and econometric models to find that biking facilities significantly impact biking over time but the relation is location specific and may occur away from downtowns.

- Noland, R.B.; Deka, D.; and Walia, R. (2011). A Statewide Analysis of Bicycling in New Jersey, *International Journal of Sustainable Transportation*, 5(5), 251-269.

  Highlights: This paper examines biking behavior in New Jersey, a bicycle friendly state like Minnesota; and finds through statewide survey and rigorous econometric analysis that demographic, socioeconomic and place-based factors are important determinants of biking.

Interesting finding: Employed, affluent, white households with children and 3 or more vehicles are more likely to bicycle.

- Pinjari, A.W., Pendyala, R.M., Bhat, C.R., & Waddell, P.A. (2007). Modeling residential sorting effects to understand the impact of the built environment on commute mode choice, *Transportation*, 34(5), 557-573.

  Highlights: This paper examines the significance of residential sorting in understanding the impacts of the built environment (BE) on travel choice behavior using a complex survey design and rigorous econometric analysis to find that residential sorting effects exist but the relation between BE and travel choice is significant even after controlling for residential sorting.

- Xing, Y., (2012). Contributions of Individual, Physical, and Social Environmental Factors to Bicycling: A structural equation modeling study of Six small US cities, Research Report UCD-ITS-RR-12-28, 1-222.

  Highlights: This paper examines the contributions of both physical (BE) and attitudinal factors on biking levels (biking for recreation and for transportation) in 6 small cities in the Western US using surveys and structural equations to model complex relationships involved. It finds that individual attitudes like biking comfort are important factors driving biking levels. Authors found that bicycle infrastructure and mixed land use patterns increase transportation biking.

- Venegas, E. C. (2009). Economic Impact of Recreational Trail use in Different Regions of Minnesota. University of Minnesota Tourism Center, University of Minnesota, Minneapolis: University of Minnesota Tourism Center.

  Highlights: This study focused on surveying recreational trail users in Minnesota to better understand their trail use perceptions and behaviors. After collecting data using mailed surveys the authors estimated the economic impact of cyclist spending in Minnesota regions. The used the IMPLAN input-output model to estimate indirect and induced impacts of the reported spending and travel behavior.

TOURISM

Bicycling's role in tourism is arguably one of the most researched topics related to the impact of bicycling. Research questions can vary widely, however. Studies reviewed focus on the role of bicycling tourism as a whole in the economy of a state or region, on the role of a bicycling-related event, and on the role of a specific bicycling trail. Common approaches to conducting research on the relationship between bicycling and tourism include surveys, input-output models, and revealed preference methods like the Travel Cost Method (TCM).

Bicycling tourism generates positive economic benefits, especially at destination trails and suburban tourist spots. Profiles of bicyclers indicate they are typically older white males living in urban locations who are highly educated with relatively higher annual incomes. Caution should be used when applying the results of economic impact studies generated in other geographical regions, as the structure of the local economy has a strong influence on economic impacts.

Articles included in this review were vetted to meet the definition of tourism established for this project. The definition was: dollars imported through participating in bicycling activities such as multi-day tours, races, and visits to destination trails.

- Bowker, J.M.; Bergstrom, J.C.; and Gill, J., (2007). Estimating the economic value and impacts of recreational trails: a case study of the Virginia Creeper Rail Trail, *Tourism Economics*, 13(2), 241-260.

  Highlights: This paper estimates the net economic value to trail users and the local economic impacts of the Virginia Creeper Rail Trail in south-western Virginia, US using a complex survey design as well as TCM (to measure value to trail users) and IMPLAN (to measure value to local businesses) and finds range for net economic value of the trail as $2.3 mn— $3.9 mn.

- CDC Policy Analysis, (2012). An Economic and Impact Analysis of the Coldwater Mountain Bicycle Trail, 1-73.

  Highlights: This paper uses an array of methods including surveys, financial analysis and econometric analysis to estimate the economic impact of the Coldwater Mountain Biking Trail in the Anniston-Oxford area of Calhoun County, Alabama and finds an encouraging range of $1.9 mn—$5.9mn but warns that this may not trickle down to rural households.

- Kashian, R; and Kasper, J. (2010). The Economic Impact of the Nature Valley Bicycle Festival: A Pilot Study of the Stage 5 Menomonie, WI Road Race, FERC Bicycle Race paper, 1-16.

  Highlights: This paper examines the local economic impact of a bicycle race in Menomonie, Wisconsin using surveys of race spectators and IMPLAN to find that the audience profile is: individuals with high education, high income who spent an average of $47 on trip related expenses. A substantial percentage of the spectators traveled from out of Menomonie and were

not related to bicycle racers implying tourism potential of such races. The extrapolated impact on the local economy was $1.2 mn and 28 jobs.

- Venegas, E. C. (2009). Economic Impact of Recreational Trail use in Different Regions of Minnesota. University of Minnesota Tourism Center, University of Minnesota, Minneapolis: University of Minnesota Tourism Center.

  Highlight: This study focused on surveying recreational trail users in Minnesota to better understand their trail use perceptions and behaviors. After collecting data using mailed surveys the authors estimated the economic impact of cyclist spending in Minnesota regions. It used the IMPLAN input-output model to estimate indirect and induced impacts of the reported spending and travel behavior.

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