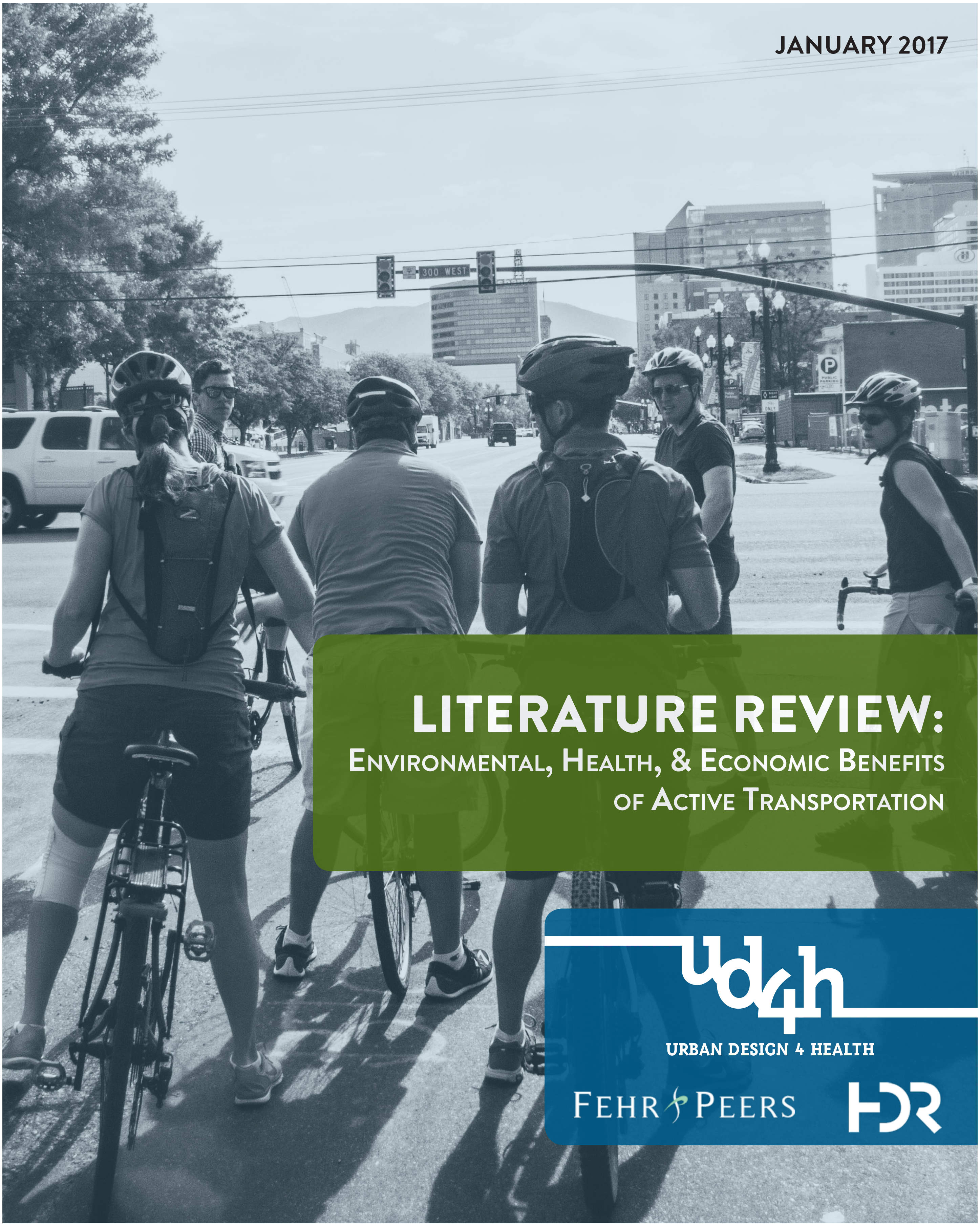
JANUARY 2017

LITERATURE REVIEW:

Environmental, Health, & Economic Benefits of Active Transportation



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Utah Active Transportation Benefits Study
Contract Number 15-1412TP

Literature Review: Environmental, Health, and Economic Benefits of Active Transportation

Task 3.1 Final Report

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1 Introduction

This document is a deliverable for Phase One's Task 3.1: *Report Preparation -- Study Review*. It provides a detailed review of economic, environmental, public health and planning studies related to estimating the costs and benefits of active transportation. Current best practices have been identified for quantifying and monetizing the active transportation costs and benefits related to such things as bicycle-related manufacturing and retail sales, tourism attributable to active transportation infrastructure, real estate value impacts, air quality and emission reduction, health impacts (from both morbidity and mortality perspectives), and monetized health benefits.

1.1 Project Context

The Utah Transit Authority and 11 agency collaborators[1] want to estimate the fiscal and health benefits[2] of active transportation to inform policy and planning decisions. Urban Design 4 Health, in partnership with Fehr & Peers and HDR Engineering (Consultant Team) are completing the Utah Active Transportation Benefits Study to achieve the following goals:

- Create evidence-based, planning decision-support tools that result in greater travel choice, while protecting the natural environmental quality and improving public health.
- Leverage stakeholder engagement, similar studies, and Utah-specific modeling to create an evidence-based, statewide estimate of active transportation benefits (walking and bicycling).
- Provide a fact-based benefit assessment of state and local spending on active transportation.
- Efficiently support and connect into larger economic and planning frameworks, including development of Utah's Unified Transportation Plan, Regional Transportation Plan, and STIP.

The results of this project will contribute to a new transportation decision-making paradigm where health, environmental, economic, and transportation costs and benefits are viewed in a more comprehensive and integrated manner. This study will contribute to Utah's national leadership developing multiple modes of transport by internalizing health and other impacts in the transportation decision-making processes.

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[1] Utah Department of Transportation, Wasatch Front Regional Council, Mountainland Association of Governments, Utah Department of Health, Bike Utah, Weber-Morgan Health Department, Salt Lake County Department of Health, Salt Lake County Office of Regional Development, Salt Lake County Bicycle Advisory Committee, Tooele County Department of Health, Park City, Intermountain Healthcare, and Governor's Office of Energy Development.

[2] In this project, the term "benefits" is a more general sense and relates to beneficial outcomes of cycling and walking activity. These "benefits" are broader than a strictly "economic benefit" which refers to an incremental change in the value of cycling or walking that relates specifically to an investment or policy. Economic benefits also differ from "economic impacts". Generally speaking, economic impacts arise as an outcome of production and expenditures whereas economic benefits arise from a change in activity or profits. Where necessary, this document will differentiate the general term of benefits from economic benefits and economic impacts.

1.2 Objective

This literature review includes methods and data used to define and monetize health benefits, including numeric rates, benchmarks and ranges that can be referenced and/or applied in the Utah setting. This information will be used for to inform the data collection effort (Phase 1 -- Task 3.3), provide potential content for the *Current Conditions Reports* at the state, regional and county levels (Phase 1 -- Task 3.4), and identify current best practices for quantifying and monetizing the active transportation costs and benefits for, the yet to funded, Phase 2 Task 4 *Benefits Analysis.*

The literature and studies selected for review cover three broad active transportation impact areas: economic, environmental, and health benefits. Documents were also reviewed to understand current methods in estimating and monetizing environmental and health benefits in addition to the economic impact of active transportation. Priority was given to information based on:

- study area (priority was given in the following order -- Utah based, neighboring states, the rest of the United States and then international), and
- time period (priority given to those done within the past 5 years).

Additional studies and reports from a variety of sources (e.g., academia, government agencies, and non-profit organizations) were identified as needed to compliment the state-level studies. The remainder of this literature review is organized by the major categories of economic, environmental, and health considerations.

2 Economic Considerations

2.1 Manufacturing and Retail

The studies reviewed here relate to the manufacturing and retail related economic impacts of active transportation. Studies focus on bicycling rather than walking and running because bicycles are clearly used on the active transportation system while walking and running gear may not. This is consistent with other economic impact of active transportation studies.

While the significance of the bicycle industry to overall economies is typically quite small (in Portland, Oregon, for example, it represents less than 0.5% of the local economy(1), it has several qualities that are important to highlight. The cycling industry spans a variety of sectors including retail, manufacturing, and even tourism. In Utah, and in other areas of the country, businesses support production and assembly as well as the sale and maintenance of bicycles. From an economic perspective, a network of small and interconnected businesses is important in providing an economic base on which an industry can grow. Proactive planning to support the development of this growing economic sector may pay off well for certain locations. Efforts to help cycling businesses locate together within targeted areas can help foster interaction and synergy. This is sometimes called an "agglomeration economy" which may happen organically or can be facilitated through government policies. The manufacturing component of this industry is one important element.

Sources Reviewed:

- The Economic Impacts of Active Transportation in New Jersey. In: Center NJBaPR, editor. (Brown & Hawkins, 2013)(2)
- The Economic Impact of the Bicycle Industry in Portland. (Hales & Anderson, 2015)(1)
- Bicycle/Pedestrian Program. Bicycling and Walking in Colorado: Technical Report Economic Impact and Household Survey Results. (Colorado Department of Transportation, 2000)(3)
- Economic Impact of Bicycling and Walking in Vermont. (Vermont Agency of Transportation, 2012)(4)

Key Metrics:

Estimated economic impacts of the active transportation (e.g., bicycling) manufacturing industry tend to follow common methods and require similar types of data. These data include:

- Numbers of industry related jobs: These data indicate the total number of jobs that are directly supported by bicycle, and other active transportation, manufacturing. Surveys of businesses and third-party data can be used to determine the number of jobs associated with bike manufacturing.
- Annual sales: Another important variable used in estimating the overall bicycle manufacturing industry includes the annual sales of businesses involved in building bicycles. Surveys and third-party data are used to determine total sales for bicycle manufacturers.
- Tax revenue: Tax rate and related information can be combined with estimates of direct, indirect and induced impacts to estimate the tax revenue impacts due to the bicycle manufacturing industry.

Several state-level studies investigated the economic benefits of bicycling. In Colorado in 1998, the bicycling industry created 513 manufacturing jobs and 700 full-time equivalent retail jobs(3).

Iowa's survey describes an $18.2 million dollar industry, with bicycle retailers estimating 22% of their business is from avid, daily bikers, 45% from weekenders, 9% children's goods, and 24% for special event rides(5). New Jersey contacted and received feedback via an online-survey from nearly 200 independent bicycle or running/walking related businesses. The average business employed 3.27 full-time and 3.84 part-time employees, spending about $116,043 in compensation (wages, salaries, etc.)(2). For every million dollars in revenue, New Jersey calculated 11.22 jobs, $339,522 in compensation, $153,771 in taxes, and $640,378 in state gross domestic product(2). Similar results have been shown in Wisconsin, where a report by the Wisconsin DOT reported the bicycling industry (consisting of manufacturing, distribution, retail, and other services) contributes $556 million and 3,418 jobs to the Wisconsin economy(6). While not a state study, Portland's bicycle industry has also contributed significantly to the local economy. In 2008, the bicycle-related economic sector was found to be nearly $90 million, with nearly 60% of that revenue coming from retail, rental, and repair, with the remaining contribution coming from manufacturing and distribution, bicycle events, and professional services(7).

A few studies made a distinction between in-state and out-of-state retail effects. An Arizona study surveyed bicycle shop owners and managers and asked to estimate how much of the revenue was attributable to out-of-state tourists(8). An estimated $57.6 million and 317 jobs were associated with manufacturing/wholesaling generated by out-of-state customers(8). In Vermont, independent sporting goods stores brought in over $39 million in revenue in 2009(4). Survey respondents estimated that 64.1% of revenues from these active transportation-oriented stores were active transportation related(4). Approximately half of the sales were to Vermont residents(4).

Table 1: Bicycle-related manufacturing and retail

State	Manufacturing Jobs	Retail Jobs	Manufacturing / Distribution Sales Revenue	Retail, Rental, Repair Sales Revenue	Total Tax Revenue
Arizona(8)	317 jobs[3]		$57.6 million	$114 million[4]	
Colorado(3)	513 jobs	700 FTEs	$762.7 million		
Iowa(5)	1,484 jobs		$18.2 million		
New Jersey(2)	2,151 jobs		$114.3 million		$49 million
Portland, OR(7)	850-1150 jobs[5]		$6 million	$54 million	$27 million
Vermont(4)	561 jobs		$39.2 million		$1.6 million
Wisconsin(6)	3,418 jobs		$556 million		

Third-Party Databases

While many of the studies above used surveys, an additional resource to understand the scale of business activity related to bicycling is through proprietary databases provide location-based lists of businesses by using standardized classification systems (e.g., Standard Industrial Classification (SIC) and the North American Industry Classification System (NAICS). InfoUSA, one such database, is built from thousands of phone directories and more than 350 new business sources, including

[3] Generated by out-of-state customers.

[4] Generated by local and out-of-state customers, excluding internet sales.

[5] Range provided

new business filings, daily utility connections, county courthouses and public record notices. InfoUSA also collects consumer information from real estate records, tax assessments, voter registration files, utility connects, bill processors, behavioral data, and more. The company also verifies its data with phone calls and other means.

Data can be assembled for individual counties, zip codes, or entire states or regions. The database is available for a particular North American Industry Classification System (NAICS) or SIC code, which facilitates identification of businesses involved in, for example, bicycle manufacturing. Information available for each business includes:

- Company Name, Mailing Address
- Type of Business – NAICS and SIC Codes
- Business Size -- Annual Sales, Number of Employees
- Franchise Indicator
- Location Status
- Year Started

The annual sales and employees information is a useful base for direct employment in bicycle industries.

Next Steps in Reviewing Methods for Utah Application

For Utah, accurate estimates of active transportation manufacturing economic impacts are best developed from local data and third-party business data to feed a Phase II economic input-output model (discussed in Section 2.9). The recommended methods to be reviewed include:

- Use third-party data sources, such as InfoUSA, to estimate total number of active-transportation-oriented manufacturers and retailers located in Utah.
- Identify any recent announcements related to active-transportation manufacturing and retailing to determine whether there are other not included in the data and survey results.

2.2 Active Transportation Tourism and Events

Active transportation infrastructure can support special events centered on active modes, such as a race or tour. Alternatively, sometimes the active transportation infrastructure itself serves as the tourism attraction. In both cases, expenditures of tourists generate economic impacts. For tourists that come from outside of the state, the economic impacts are overall gains for the state, whereas tourism expenditures from state residents reflect a transfer of economic impact within the state. Both are important outcomes for tourism-oriented regions of Utah, and the state overall.

Sources Reviewed:

- An economic impact study of bicycling in Arizona: out-of-state bicycle tourists and exports. (Arizona Department of Transportation, 2013)(8)
- The Economic Impacts of Walking of Active Transportation in New Jersey. (Brown & Hawkins, 2013)(2)
- National Visitor Use Monitoring Results for Moab Field Office. (Bureau of Land Management, 2007)(9)
- Bicycling and Walking in Colorado: Technical Report Economic Impact and Household Survey Results. (Colorado Department of Transportation, 2000)(3)

- Valuing Bicycling's Economic and Health Impacts in Wisconsin. (Grabow et al., 2010)(10)
- The Economic Benefits of Mountain Biking at One of Its Meccas: An Application of the Travel Cost Method to Mountain Biking in Moab, Utah. (Fix & Loomis, 1997)(11)
- Economic and Health Benefits of Bicycling in Iowa (Lankford et al., 2011)
- Economic Impact Study: 2009 USA Cycling Junior/U23/Elite National Road Cycling Championships in Bend, Oregon. (Lindberg, 2009)(12)
- Bicycle Tourism in Maine: Economic Impacts and Marketing. (Maine Department of Transportation, 2001)(13)
- Do Health Benefits Outweigh the Costs of Mass Recreational Programs? An Economic Analysis of Four Ciclovia Programs. (Montes et al., 2012)(14)
- The Economic Significance of Bicycle-Related Travel in Oregon: Detailed State and Travel Region Estimates. (Travel Oregon, 2013)(15)
- Economic Impact of Bicycling and Walking in Vermont. (Vermont Agency on Transportation, 2012)(4)

Key Metrics:

Estimated economic impacts of tourism expenditures tend to follow common methods and require similar types of data. These data include:

- Numbers of and origins of participants: These data indicate the total annual number of participants and days spent walking, running and bicycling. With respect to special events, it is often possible to develop reasonable estimates of the number of participants, and accompanying persons based on historical event records and ideally, participant surveys. These surveys can also indicate out-of-state residents. Data on the number of more casual cyclists or hikers would be developed from surveys of travelers to the state or special locations (e.g. national parks) who engage in active transportation for part of their trip.
- Daily expenditures, total and by type, per participant: Often, traveler or event participant surveys are implemented specifically to estimate average daily direct expenditures per person-day. The surveys aim to assess expenditures in several common categories (e.g. lodging, food, transportation, and miscellaneous purchases), numbers of persons in a group and the length of stay – the combination of which can determine the average expenditures per person-day. These estimates of direct expenditures can then be used as inputs into economic impact models to estimate the follow-on indirect and induced effects on the wider local economy.
- Other information: Surveys also aim to better understand tourists' trip purpose, and the importance of bicycling, running or hiking to the experience, along with any preferences for local transportation, lodging and food choices, and other amenities. These surveys can also be used to assess the tourists' perspectives on the adequacy of active transportation infrastructure and supporting services. These data are important in determining how much of tourists' expenditures can be attributable to their engagement in active transportation activities.

Several studies examined the economic benefit of bike recreation and tourism in one of the most popular recreation areas in the state – Moab. A study by Fix and Loomis (1997) found the consumer surplus for bike trails in Moab was between $197 and $205 per trip ($53.08-$55.27 per individual per day)(11).

A similar study used survey data to develop a predictive model of users' travel costs, calculating how much each trip cost, both in direct expenditures and the opportunity cost of not working in order to visit. The study found that the average trip demand per person per season was 2.5. times and estimated that $282 were spent per trip. The best-fitting model suggested that individuals' total benefit for a trip to Moab for mountain biking is $586 per trip. The total annual economic values of mountain bicycling in Moab was estimated at $1.33 million(16).

According to data collected in FY 2006 through the National Visitor Use Monitoring Survey conducted by the BLM Moab Field Office, biking represented 17% of all user activity on BLM lands. The study translated such bike activity into 313 jobs and $8.4M in labor income(9).

Zacharia Levine, the Grand County Community Development Director, presented materials related to active transportation benefits for a Mobile Active Transportation Tour (MATT) hosted in Moab in June of 2015. Mr. Levine shared these materials following the first Active Transportation Benefits Study Stakeholder meeting. These resources were reviewed and are summarized below.

In the "mountain states" (AZ, CO, ID, NM, MT, UT, NV, WY), bicycling contributes $6.2 billion annually to the regional economy and:

- Supports more than 60,000 jobs across the region
- Generates more than $1 billion in annual state and federal tax revenues
- Produces nearly $4.1 billion annually in retail sales and services
- $429 million in bicycling gear sales and services
- $3.7 billion in bicycling trip-related expenditures(17)

Events, particularly elite races, can be a significant economic driver. For example, a study of the 2009 USA National Road Cycling Championships estimated $1.44 million in direct tourism spending, with stays nearly twice as long as other tourism stays in Bend, Oregon(12). In another example, New Jersey estimates that bicycling, running, and walking participants spent over $35 million associated with nearly 200 transportation-related events; $10 million of the $35 million was spent by tourists from out of state(2).

The table below presents results from a study in Wisconsin that estimated total impacts (i.e., direct, indirect and induced) from spending per person-day for residents and non-residents on bicycling-related activities throughout the state(10). The total impacts per 100 person-days, normalized to 2016$, include an estimated $50,737 in direct impacts, $1,557 in indirect impacts, $1,786 in induced impacts, and 0.11 jobs(10).

Table 2: Average Expenditures for Bicycle-related tourism (Normalized from Grabow et al (2010))

Grabow et al. (2010) – Wisconsin Application	**Per 100 person-days (2016$)**				
	Daily Spending	**# Jobs**	**Indirect**	**Direct**	**Induced**
		0.11	**$1,557**	**$50,737**	**$1,786**
Road Touring - Residents	$44			$4,373	
Road Touring - Non-Residents	$59			$5,918	
Trails - Residents	$20			$1,988	
Trails - Non-Residents	$38			$3,752	
Single-day Bike Events/Tours - Residents	$84			$8,418	
Single-day Bike Events/Tours - Non-Residents	$84			$8,418	
Multi-Day Tours - Residents	$89			$8,935	
Multi-Day Tours - Non-Residents	$89			$8,935	

Data collected in Vermont for 2009 expenditures associated with the 40 major bicycling and running events showed over 16,000 participants and an additional 28,000 associated family and friends(4). The economic impact of both participants and their family and friends generated $6.2 million in 2009 in Vermont; over 2/3 from out-of-state visitors(4). The breakdown from these Vermont events is included in the table below.

Table 3. Estimated tourism expenditures related to major bicycling and running events in Vermont, 2009. (Reproduced from Vermont Agency of Transportation, 2012, Table 8, sources Event sponsors, Resources Systems Group, Inc.)

	Economic Output Generated					
	Registration Fees	**Lodging**	**Food/Beverage**	**Gas/Fuel**	**Shopping/Rec**	**Totals**
Vermont Residents	$434,720	$135,060	$398,428	$605,503	$461,312	$2,035,022
Vermont Visitors	$691,756	$902,398	$1,269,738	$726,953	$575,182	$4,166,027
Totals	$1,126,476	$1,037,458	$1,668,166	$1,332,456	$1,036,494	$6,201,050
Per Participant (n=16,189)	$69.58	$64.08	$103.04	$82.31	$64.02	$383.04
Per Participant, Family and Friends (n=44,416)		$23.36	$37.56	$30.00	$23.34	$139.61

Other states have investigated the bicycling tourism more broadly. Half of all summer visitors to Colorado's ski resorts spent time bicycling and most (70% of out of state visitors and 40% of local Coloradoans) said they would have chosen an alternative vacation destination if bicycling was not available(3). Research by the Maine Department of Transportation indicates the economic benefits of statewide bicycle tourism included $36.3 million in direct spending by over 2 million bicycle tourists. The multiplier effect of these direct expenditures amounts to $66.8 million dollars, including the indirect and induced impact of $30.5 million(13). The total impact includes earnings of over $18.0 million – earnings, which are the sum of the wages and salaries attributable to bicycle tourism, equal to 1,200 full-time equivalent jobs(13). The Institute for Transportation Research and

Education at North Carolina State University found that the total annual impact of bicycle tourism in the Outer Banks of North Carolina included $60 million in direct spending, along with the creation and support of 1,400 full-time equivalent jobs(18).

Arizona's study focused on out-of-state tourism on retail effects. Bicycle shop owners and managers were surveyed and asked to estimate how much of the revenue was to out-of-state tourists. Out-of-state tourists attending select events were also asked about their spending. Statewide, the study estimated $30.6 million (in 2013$) and 404 jobs were associated with out-of-state tourism(8).

Table 4: Estimated tourism spending (direct and indirect) summary

Study	# of tourists	Spending				Notes
		Total Direct	Per Tourist	Total Indirect	Per Tourist	
AZ	36,500	$30,600,000	$837.04	$13,241,000	$362.77	Based on out-of-state tourists only
Maine	2,000,000+	$36,300,000	$18.15	$30,500,000	$15.25	
Outer Banks, NC	680,000	$60,000,000[1]	$88.24			
Moab, UT	157,342	$1,330,000[1]	$586			Estimate based on mountain bikers only
VT	44,146	$6,201,0500	$139.61	$9,470,000	$213.21	

[1]Includes both direct and indirect

Next Steps in Reviewing Methods for Utah Application

- Estimate total number of active-transportation-oriented tourists, from within and outside Utah by (a) identifying major annual special events across the state and (b) identifying the major regions supporting active transportation tourism. Use existing Utah-based estimates of economic impacts, such as the Moab study(16), when available.
- Identify the key types and locations of active transportation infrastructure used by tourists on their trips. This includes frequency and estimated miles or time of use.
- Develop economic input-output impact model (e.g., IMPLAN) in Phase II to assess overall impact of daily expenditures for all participants, relative to their degree of activity in walking, running or bicycling.

2.3 Value Capture – Increased Real Estate Value

Active transportation facilities serve as an amenity that can increase the desirability and the price of nearby property. This is a relatively new phenomenon as shift towards the demand for and responding creation of walkable environments continues to grow. One of the most evident examples of land value increase due to an investment in active transportation infrastructure was the "HighLine" in New York City. This example is instructive as it shows the potential in certain urbanized settings where value can result from serving unmet demand for ways to navigate urban environments safely without vehicles present. The concepts are transferrable to less urbanized areas like many found within Utah. This area of research around land value capture associated with specific investments in active transportation infrastructure is developing and still quite limited.

However, there is evidence in the literature around two different types of real estate premiums related with active transportation overall: (1) increased values from being closer than average to a trail and (2) increased values from living in an area with higher walkability. This section is organized around these two themes.

Sources Reviewed:

- The relative impacts of trails and greenbelts on home price. (Asabere & Huffman, 2009)(19)
- Walkable Neighborhoods: An Economic Development Strategy. (Bliesner, Bouton & Schultz, 2010)(20)
- Walking the Walk: How Walkability Raises Home Values in U.S. Cities. (Cortright, 2009)(21)
- Demonstrating the Benefits of Green Streets for Active Aging: Final Report to EPA. (Dill et al., 2010)(22)
- Does walkability matter? An examination of walkability's impact on housing values, foreclosures and crime. (Gilderbloom, Riggs, and Meares, 2015)(23)
- Omaha Recreational Trails: Their Effect on Property Values and Public Safety. (Greer, 2000)(24)
- Two Approaches to Valuing Some of Bicycle Facilities' Presumed Benefits: Propose a session for the 2007 National Planning Conference in the City of Brotherly Love. (Krizek, 2006)(25)
- Walk this Way: The Economic Promise of Walkable Places in Metropolitan Washington, D.C. (Leinberger & Alfonzo, 2012)(26)
- Property values, recreation values, and urban greenways. (Lindsey, Man, Payton, & Dickson, 2004)(27)
- Walk Score and Multifamily Default: The Significance of 8 and 80. (Pivo, 2013)(28)
- The Walkability Premium in Commercial Real Estate Investments. (Pivo & Fisher, 2011)(29)
- Understanding the impact of trails on residential property values in the presence of spatial dependence. (Parent & Hofe, 2013)(30)
- Project Report for Property Value / Desirability Effects of Bike Paths Adjacent to Residential Areas. (Racca & Dhanju, 2006)(31)
- Residential Land Values and Walkability. (Rauterkus & Miller, 2011)(32)
- A Hedonic Spatial Panel Approach to Estimating the Impact of Network Access to Bike and Public Transit Facilities on Housing Prices. (Welch et al, 2015)(33)

Key Metrics:

- Property value impacts from proximity/access to active transportation facilities

Property values – both commercial and residential – are generally positively affected by proximity to active transportation facilities and/or high walkability areas. Table 5 provides studies investigating the effects of active transportation or land use as measured by proximity to multi-use trails, bike lanes, and other active transportation facilities for residential purposes. Table 11 lists studies investigating the effects of active transportation or land use as measured by walkability for either residential or commercial properties.

Most residents perceive trails as a positive amenity, although rural and suburban residents may value trail access differently(24,25). Hedonic studies measure the empirical benefits and largely confirm those perceptions. Studies show positive effects of multi-use trail

Table 5: Description of studies addressing real estate effects of active transportation.

Study	Location	Type of property	Type of facility	Measurement	Outcome
Greer (2000)(24)	Omaha, NE	Residential	Recreational trails	Perceived benefit (ease of sell or price) of selling home within 1 block of trail	Overall, 81% felt that the nearby trail's presence would have a positive effect or no effect on the ease of sale of their homes. Only 6.2% of homeowners stated that their homes sold more slowly due to presence of a trail and only a few residents perceived that a trail had a harmful economic impact. Urban-rural difference: 27.5% of rural property owners believed that proximity to trails slowed the sale of their property, while only 10.8% believed proximity to trails increased the speed of sale
Lindsey, Man, Payton, & Dickson (2004)(34)	Indianapolis	Residential	Multi-use paths	Home values	Some, but not all greenways have positive impacts on property values. Homes near Monon Trail sold, 11.4% higher than average price. Average price for residential properties in other greenway corridors was same as average for all sales. Average price for homes in conservation corridors 26.5% higher than average price (all 1999$)
Krizek (2006)(25)	Twin Cities, MN	Residential	Multi-use trail	Real estate prices	$510 increase in value for homes in urban areas that were near (400m) to off-street bicycle facilities; not consistent in suburbia
			Bike lanes		No significant effect on busy streets.
Racca & Dhanju (2006)(31)	Delaware	Residential	Bike paths	Home values	Proximity to a bike path (within 50 meters) increase property values by about $8800
Asabere & Huffman (2009)(19)	San Antonio, TX	Residential	Multi-use trail	Price premium for abutting trail	Trails, greenbelts, and trails with greenbelts associated with 2, 4, and 5% price premiums, respectively
Welch et al (2015)(33)	Portland, OR	Residential	Multi-use local paths	Value per foot closer in proximity to trail access point (2014 US $)	$1.72
			Multi-use regional paths		$0.35
			Bike lanes		-$3.91
Parent & Hofe (2013)(30)	Miami, OH	Residential	Multi-use trail	Value per foot closer in proximity to trail access point (2014 US $)	$4.19

proximity(19,25,27,30,33). Evidence for bike lanes is more mixed. Several studies have shown negative property value effects of bike lanes(25,33); this may be explained bike lanes located on busier roads that are generally deemed less desirable as residential location.

Table 6: Description of studies addressing real estate effects of walkability.

Study	Location	Type of property	Measurement		Outcome
Cortright (2009)(21)	15 housing market (National)	Residential	WalkScore	Home values	A one point increase in Walk Score was associated with between a $500 and $3,000 increase in home values
Dill et al (2010)(22)	Portland, OR	Residential	Green Street Treatment	Price	Green street treatments were positively associated with walking. Each additional green street treatment within 500 feet was associated with a $968 increase in sales price. A relatively small $1.30 increase in price for each additional linear foot away from a green street treatment also was found.
Bliesner, Bouton & Schultz (2010)(20)	San Diego, CA	Residential	Walkability	Home values, Notice of Defaults-Foreclosures	Protective effect (less decline) during recessions, 83% of variance in walkable vs. non-walkable areas are explained by # of retail and service establishments within the zone, notice of default mortgage foreclosures lower in neighborhoods defined as walkable
Pivo & Fisher (2011)(29)	National	Commercial and residential apartments	WalkScore	Price	4.8%-8.2% increase in price from 10 point increase in walk score
Rauterkus & Miller (2011)(32)	Jefferson County, Alabama	Residential	WalkScore	Price of land	Values increase as walkability increases; however, this effect reverses in more car dependent, suburban settings.
Leinberger & Alfonzo (2012)(26)	Washington , DC	Commercial	WalkScore	Rents per sq. ft.	A place with good walkability (WalkScore of 4), on average, commands $8.88/sq. ft. per year more in office rents and $6.92/sq. ft. per year higher retail rents, and generates 80% more in retail sales as compared to the place with fair walkability
Pivo (2013)(28)	National	Residential (multi-family housing)	WalkScore	Mortgage default risk	Higher WalkScore reduces mortgage default risk, but relationship is not linear - thresholds at Scores of 8 and 80, above which significant declines in mortgage risk occurred
Gilderbloom, Riggs, & Meares (2015)(23)	Louisville, KY	Residential	WalkScore	Housing values	Higher walkability results in higher housing values

There is also a growing literature of hedonic studies linking walkability (usually measured using location-based values from WalkScore[6]) to both residential (20,21,23,28–30) and commercial (26,29) property values. Gilderbloom, Riggs, and Meares (2015)(23) have linked higher walkability to higher housing values. Several studies have shown a protective effect of walkability during recessions, resulting in fewer defaults and/or greater price premiums(20,26,28). In the commercial context, Pivo & Fisher (2011)(35) have shown an association of a 4.8% to 8.2% increase in prices in relation with a 10-point increase in WalkScore. These findings are from a cross-sectional study design; therefore results are an association between land value and WalkScore. While likely, it is not possible to assume a given increase in a WalkScore value will cause land values to increase – or to be sure under which contexts this would be the case. Studies designs that measure changes in land values over time in relation with changes in connectivity and accessibility through active transportation from infrastructure investment and increases in walkability are needed. These longitudinal studies can document causal impacts (financial benefits) and will advance the ability to promote more investment. Like bike lanes, the property value associations with walkability appears to be different in urban versus suburban settings(23); this suggests caution in monetizing using walkability in non-urban areas.

Because multi-use trails have been studied the most in the residential setting, Table 7 (reproduced from Welch et al, 2015(33)) provides factors that could be applied in the Utah setting. Note that bike lanes do not show a consistently positive effect, suggesting that calculating a real estate benefit from bike lanes is not appropriate at this time.

Table 7: Comparison of findings from past relevant hedonic studies. Reproduced from (Welch et al., 2015).

Study	Facility Type	Location	Value per foot closer in proximity to trail access point (2014 US $)
(Lindsey, Man, Payton, & Dickson, 2004)(27)	Multi-use paths	Indianapolis, IN	$6.95
(Krizek, 2006)(25)	Multi-use paths Bike lanes	Twin Cities, MN	Positive effect for non-roadside trails. No significant effect on busy streets.
(Asabere & Huffman, 2009)(19)	Multi-use paths	San Antonio, TX	$3,107.64[1]
(Parent & Hofe, 2013)(30)	Multi-use paths	Miami, OH	$4.19
(Welch et al., 2015)(33)	Multi-use local paths Multi-use regional paths Bike lanes	Portland, OR	$1.72 $0.35 $-3.91

[1]Increase in value for houses abutting a trail versus houses not immediately abutting a trail.

Next Steps in Reviewing Methods for Utah Application:

- Residential:
  - Given sufficient information about multi-use trails, apply range from Welch et al, 2015 to multi-use paths.
  - There is insufficient evidence for applying a residential real estate factor for proximity to bicycle lanes.
- Commercial:
  - There is insufficient evidence related to walking/bicycling infrastructure for

[6] www.walkscore.com

universal application.
- Investigate potential to selectively use Walkscore for illustrative purpose and apply Pivo & Fisher, 2011 (e.g. range of 4-8% price increase for each 10-point increase in Walkscore)

2.4 Trip Making and Infrastructure

This section investigates current methods and assumptions for estimating the impact of walking and bicycling infrastructure on shifting travel by motorized mode to walking or bicycling.

Sources Reviewed:

- Cycling to work in 90 large American cities: New evidence on the role of bike paths and lanes. (Buehler & Pucher, 2012)(36)
- The Impact of Bicycling Facilities on Commute Mode Share. (Cleaveland & Douma, 2008)(37)
- Bicycle Commuting and Facilities in Major U.S. Cities: If You Build Them, Commuters Will Use Them. (Dill & Carr, 2003)(38)
- Many pathways from land use to health. (Frank et al., 2006)(39)
- Promoting Cycling for Transport: Research Needs and Challenges. (Handy, van Wee & Kroesen, 2014)(40)
- Accounting for the short term substitution effects of walking and cycling in sustainable transportation. (Piatkowski, Krizek, & Handy, 2015)(41)
- Bicyclists as Consumers: Mode Choice and Spending Behavior in Downtown Davis, California. (Popovich & Handy, 2014)(42)

Key Metrics:

Numbers of current walking and bicycling trips
Reduced vehicle miles traveled (VMT) associated with increased bike lanes/trails

Many factors impact people's choices to walk or bicycle, including attitudes, health levels, and time availability. The presence of safe, direct and convenient infrastructure (e.g., sidewalk, bicycle lanes and trails) is not the most important reason according to the results from the Utah Household Travel Survey. Of the people who participated in the survey and did not report a walking trip, 2.3% indicated that a lack of sidewalks or trails was the reason for not choosing to walk(43). Of the people who did not report a trip by bicycle, 7.6% cited a lack of infrastructure (too few bike lanes, paths, trails, etc.) as the reason. The second highest reason given for not biking was attitudinal –"do not enjoy biking, do not feel safe"(43). The lack of feeling safe can also be impacted by infrastructure improvements(43).

One of the only available published articles shows that the substitution effect (walked/bicycled instead of driving) ranges significantly across cities – between 25% and 72.4%(41). Piatkowski et al. also show, through logistic regressions, that individual factors explain the substitution effect: increased age predicts substituted walking behavior, and the number of car trips per week and helmet use predicts bicycle substitution(41). Another intercept surveys of Los Angeles bicyclists at nineteen Metro Rail stations found that 27% of bicycle-rail trips replaced a motor vehicle trip(44).

Table 8: Mode shift, Substitution, and VMT (Reproduced from Piatowski, Krizek, & Handy, 2015 (41))

Substitution responses and characteristics of substitution vs. non-substitution travelers.							
Responses to: What would you have done if you hadn't walked/biked for this trip?							
Location	**Driven**	**Used Bus Or Light Rail**	**Cycled / Walked (Which Ever Not Currently Doing)**	**Would Not Have Made The Trip At All**	**Would Have Made The Trip At A Later Time**	**Other**	**Total**
Denver	23.70%	32.20%	20.50%	18.60%		5.00%	100%
Boulder	57.10%	30.30%	9.00%	3.60%			100%
Littleton	72.40%	17.30%			6.80%	3.50%	100%
Davis	25.00%	8.30%	47.20%	11.20%		8.30%	100%
Sacramento	27.30%	45.40%	9.10%		9.10%	9.10%	100%

Despite few studies explicitly investigating the substitution effect, there is an increasing literature inferring the built environment's effect on substitution levels(40,41). Bike infrastructure (lanes and paths) has been studied as an explicit lever in mode shift and physical activity. For example, Dill & Carr (2003) studied the effects of increased bicycle lanes on mode share for 33 large U.S. cities (not including New York City) and showed that each additional mile of bicycle lane per square mile is correlated with an approximate 1% increase in the share of bike-to-work trips(38). More recently, Buehler and Pucher (2012) looked at bicycling commuting rates in 90 U.S. cities. They showed up to one third of bicycle commuting can be explained by the bike lane and path network(36). Additionally, a 10% increase in bike lanes resulted in a 3.1% increase in bicycle commuters; similarly, a 10% increase in bike paths was associated with a 2.5% increase in bike commuters. Studies that include walking are also available. For example, a study in King County, Seattle, WA found that a 5% increase in walkability of a community reduced vehicle miles traveled per capita by 6.5% and increased time spent in physically active travel by 32.1%(39).

Six cities that experienced new bicycle facility construction during the 1990s were analyzed to determine how these facilities influenced localized bicycle commuting rates and to identify possible contextual factors influencing bicycle commuting rates(37). From this, it was found that 'build it and they will come' theory is not universally applicable as contextual factors, including overall network connectivity are an important element in determining the effectiveness of new commuting facilities(37). Still, other studies are showing that some residents are sensitive to high-quality infrastructure. For instance, bicycle boulevards are becoming increasingly popular as a means of encouraging alternate modes of transportation. Residents in Portland, Oregon were surveyed to determine the impact on quality of life, safety, sense of community, and bicycling use. 42% of respondents said living on a bicycle boulevard makes them more likely to bike, the majority of whom did not self-select to live on a bicycle boulevard. The study also found that 39% of the residents that did not "self-select" to move to the bicycle boulevard reported that living on a bicycle boulevard makes them more likely to bike(45).

Guo and Gandavarapu (2010) estimated that completing the sidewalk network in a typical U.S. town would increase average per capita active travel 16% (from 0.6 to 0.7 miles per day) and reduce automobile travel 5% (from 22.0 to 20.9 vehicle-miles), or about 10 miles of reduced VMT for each mile of increased walking(46). For this reason, active transportation infrastructure remains an important policy lever in managing overall transportation demand.

Next Steps in Reviewing Methods for Utah Application:

- Results of the Utah Household Travel Survey and the other studies referenced above provide context and example finding regarding the impact of infrastructure on the levels of walking and bicycling.

2.5 Active Transportation Travel Costs

One reason for understanding the substitution of active transportation for other modes of travel – particularly driving in a single-occupancy vehicle – is important in that doing so also results in individual household benefits associated with travel costs. For example, McCann et al (2000) found that households in automobile-dependent communities devoted about 50% more, $3,000 on average, to transportation than households in communities with better bicycle and pedestrian facilities(47). Moreover, Cortright (2010) found that New Yorkers save approximately $19 million per year, on average, in comparison to other consumers in other large U.S. cities due to their reduced reliance on automobiles(48).

Sources Reviewed:

- March Transit Savings Report: Savings Bloom When You Ride Public Transit. (American Public Transportation Association, 2015)(49)
- New York City's Green Dividend. (Cortright, 2010)(48)
- Driven to Spend: The impact of sprawl on household transportation expenses. (McCann et al., 2000)(47)
- Pedaling to prosperity (Sierra Club et al., 2012)(50)
- Annual Cost to Own and Operate a Vehicle Falls to $8,698, Finds AAA. (Step, 2015)(51)
- Economic Impact of Bicycling and Walking in Vermont. (Vermont Agency on Transportation, 2012)(4)

Key Metrics:

- Travel costs by mode per mile

Consumer costs consist of both the costs to the consumer for using the various types of active transportation, as well as the additional consumer purchases generated due to walking and biking. These costs can be estimated based on tax reports for specific districts, surveys of businesses, and surveys of active transportation users. Developing a list of costs by mode type can be a useful tool to present cost savings to consumers. For example, the cost to own and operate a vehicle per year is more than the costs to own and operate a bicycle. Studies have estimated the costs to individuals for commuting by automobiles, transit, bicycles, walking, and several other methods.

Commuting costs by mode are readily available through several studies, including the American Automobile Association (AAA), the American Public Transit Association (APTA), transit agencies, and academic studies. Costs estimates from three are provided below. It is noted that each has different automobile costs ranging from $8,220(50) to $8,698(52).

- Automobiles: AAA collects data regularly to estimate the average cost of owning a vehicle by totaling the average costs for fuel, finance charges, depreciation, insurance, maintenance, license / registration, and tires. One report estimates that average annual costs to own and operate a vehicle are about $8,698(53).

- Transit: APTA study estimates the monthly commuting cost by transit by calculating the average cost of taking public transit by determining the average monthly transit pass of local public transit agencies across the country. This study estimates that riding public transit can save up to $9,234 annually(49).
- Bicycle Commuting: A study prepared by the League of American Bicyclists, Sierra Club, and the National Council of La Raza, estimated the annual costs of owning a bike to be $308 per year compared to $8,220 for the average car, showing a significant savings(50).

The Vermont Agency of Transportation (2012) used Victoria Transport Policy Institute(54) cost categories, adjusted to 2009$, to estimate an approximate $34.5 million in cost savings from 36.5 million miles of biking and walking instead of driving(4). This estimate was derived using the Victoria Transport Policy Institute cost categories (Table 9) and updated/localized values for those factors(4,54).

Table 9: Transportation Cost Category Definitions (Source: Table 6.1-1 Transport Cost Categories, (Victoria Transport Policy Institute, 2009))

Transport Related Cost Category	Definition
Vehicle Ownership	Fixed costs of owning an automobile, bike and walking
Vehicle Operation	Variable vehicle costs, including fuel, oil, tires, tolls and short-term parking fees.
Operating Subsidy	Financial subsidies for public transit services.
Travel Time	The value of time used for travel.
Internal Crash	Crash costs borne directly by travelers.
External Crash	Crash costs a traveler imposes on others.
Internal Health Ben.	Health benefits of active transportation to travelers (a cost where foregone).
External Health Ben.	Health benefits of active transportation to society (a cost where foregone).
Internal Parking	Off-street residential parking and long-term leased parking paid by users.
External Parking	Off-street parking costs not borne directly by users.
Congestion	Congestion costs imposed on other road users.
Road Facilities	Roadway facility construction and operating expenses not paid by user fees.
Land Value	The value of land used in public road rights-of-way.
Traffic Services	Costs of providing traffic services such as traffic policing, and emergency services.
Transport Diversity	The value to society of a diverse transport system, particularly for non-drivers.
Air Pollution	Costs of vehicle air pollution emissions.
Green House Gas (GHG)	Lifecycle costs of greenhouse gases that contribute to climate change.
Noise	Costs of vehicle noise pollution emissions.
Resource Externalities	External costs of resource consumption, particularly petroleum.
Barrier Effect	Delays that roads and traffic cause to nonmotorized travel.
Land Use Impacts	Increased costs of sprawled, automobile-oriented land use.
Water Pollution	Water pollution and hydrologic impacts caused by transport facilities and vehicles.
Waste	External costs associated with disposal of vehicle wastes.

The Vermont study found costs per mile per mode (based on the extensive set of costs considerations listed in the above table) to be:

Table 10: Vermont Cost per Mile per Mode Estimates (Source: Vermont Agency on Transportation (2012))(4,54)

Mode	Costs per Mile	
	Urban	Rural
Auto	$1.21	$0.90
Bicycle	$0.40	$0.38
Walk	$0.95	$0.95

It is important to note that the cost of the time spent traveling plays a large factor in the walking costs. The time spent walking for a given distance is significantly more than for bicycling and driving, and that is reflected in the costs per mile factors provided through this method. Other methods focus on a smaller set of factors more directly related to the costs of purchasing, operating and maintaining an automobile and a bicycle, such as shown in the table on the next page.

Table 11: Per Mile Costs by Mode (Reproduced from Pedaling from Prosperity, by Sierra Club et al., 2012) (50)

Cost per mile	Notes	Source
AUTO: $0.62	Value used is the average of small-, medium-, large-sedan, SUV and Van estimated annual costs.	http://newsroom.aaa.com/2011/04/costof-owning-and-operating-vehicle-in-u-sincreased-3-4-percent-according-to-aaas- 2011-your-driving-costs-study/
BICYCLE: $0.10	Value used is mid-point of $0.05-$0.15 per mile estimate	Litman, Todd, Transportation Cost and Benefit Analysis II – Vehicle Cost, www.vtpi.org/tca/tca0501.pdf

Recommendations for Utah Application:

- Use a Utah-tailored version of the approach used by Vermont, which followed the methods developed by the VPTI.
- Localize, update and adjust per mile costs to a common, current year value.
- Apply per mile costs to miles traveled by each mode in Utah.
- Based on miles bicycled and walked, determine costs savings if those miles were instead traveled using a private automobile.

2.6 Infrastructure Costs

Costs associated with active transportation infrastructure can be divided into two broad categories: capital costs (one-time costs) and operating costs (regular maintenance and scheduled repair). Data specific to active transportation infrastructure can sometimes be difficult to identify because while "some consists of dedicated facilities like bicycle lanes on streets or walking and bicycle paths, others (like roadway shoulders) are not primarily built for non-motorized users"(4)(Vermont Agency of Transportation, 2012, p. 16).

Sources Reviewed:

- Salt Lake City Pedestrian & Bicycle Master Plan. (Alta Planning + Design, 2015)(55)
- An economic evaluation of health-promotive built environment changes. (Guo & Gandavarapu, 2010)(56)
- Safer Streets, Stronger Economies: Complete Streets project outcomes from across the

country. (Smart Growth America, 2015)(57)
- Economic Impact of Bicycling and Walking in Vermont. (Vermont Agency on Transportation, 2012)(4)
- Evaluating Active Transportation Benefits and Costs: Guide to Valuing Walking and Cycling Improvements and Encouragement Programs. (Victoria Transport Policy Institute, 2016)(58)
- Regional Transportation Plan 2015-2040. (Wasatch Front Region Council, 2015)(59)

Key Metrics:
- Cost of active transportation facilities (construction, operations, and maintenance)
- Reduction in roadway maintenance

Active Transportation Infrastructure Costs

The 2015 regional transportation plan for the Wasatch Front Regional Council indicates approximately 1319 miles of Base Bicycle routes (estimated cost of $244,015,000), and approximately 615 miles of Regional Priority routes (estimated cost of $113,775,000) are planned to be built(59). At this amalgamated level (not differentiated by facility type), the per mile cost is $185,000(59). The range by facility type can be large. For example, the 2015 Salt Lake City Pedestrian and Bicycle Master Plan includes the tables below with capital (construction) and maintenance costs by facility type(55):

Table 12: Per Mile Capital Costs Estimate Ranges (Reproduced from Table 8.3, Salt Lake City Pedestrian & Bicycle Master Plan, Alta Planning + Design, 2015)(55)

Bikeway Type	Mileage Range	Cost/Mile		
		Low	High	Assumed Average
Multi-Use Path	40-50	$ 575,000	$ 2,600,000	$ 800,000
Protected Bike Lane	20-25	$ 40,000	$ 3,000,000	$ 600,000
Buffered Bike Lane	35-45	$ 17,500	$ 135,000	$ 25,000
Neighborhood ByWay	45-55	$ 200,000	$ 1,300,000	$ 350,000
Conventional Bike Lane	25-35	$ 12,000	$ 72,000	$ 20,000
Shared Lane Markings	15-25	$ 1,200	$ 17,000	$ 3,000
Signed Shared Roadway	1-5	$ 4,000	$ 5,200	$ 4,500

Table 13: Per Mile Annual Maintenance Cost Estimate Ranges (Reproduced from Table 8.4, Salt Lake City Pedestrian & Bicycle Master Plan, Alta Planning + Design, 2015)(55)

Bikeway Type	Mileage Range	Cost/Mile		
		Low	High	Assumed Average
Multi-Use Path	40-50	$ 3,000	$ 85,000	$ 5,000
Protected Bike Lane	20-25	$ 1,200	$ 25,000	$ 2,000
Buffered Bike Lane	35-45	$ 5,000	$ 12,000	$ 7,000
Neighborhood ByWay	45-55	$ 2,000	$ 8,000	$ 3,000
Conventional Bike Lane	25-35	$ 2,000	$ 5,000	$ 3,000
Shared Lane Markings	15-25	$ 1,000	$ 2,500	$ 1,500
Signed Shared Roadway	1-5	$ -	$ 500	$ 250

The Utah Bicycle & Pedestrian Master Plan Design Guide also provides cost estimates for an even more detailed set of facilities and their components (Some infrastructure costs are shared between pedestrian and automobile uses, such as bridges that support both roads and sidewalks. Unit costs extracted from multi-modal estimates should include only a portion of these shared-use costs. Capital costs also come in the form of programs that contribute to active transportation, such as Safe Routes to School, Share the Road and bicycle commuter guides, pedestrian and bicycle facility plans, and recreational trail plans(4). These costs are typically dwarfed by the physical infrastructure costs mentioned above.

Table 14 below).

Some infrastructure costs are shared between pedestrian and automobile uses, such as bridges that support both roads and sidewalks. Unit costs extracted from multi-modal estimates should include only a portion of these shared-use costs. Capital costs also come in the form of programs that contribute to active transportation, such as Safe Routes to School, Share the Road and bicycle commuter guides, pedestrian and bicycle facility plans, and recreational trail plans(4). These costs are typically dwarfed by the physical infrastructure costs mentioned above.

Table 14: General Pedestrian and Bicycle Facility Cost Estimates Ranges (Reproduced from Table 8.1, Salt Lake City Bicycle and Pedestrian Master Plan Design Guide, Metro Analytics, 2015)(60)

Pedestrian Facilities	**Unit**	**Cost**
Sidewalk (5-foot width)*	Linear foot	$80 w/ curb and gutter $50 w/o curb and gutter
Crosswalk: High visibility (thermoplastic)	Linear foot	$500
Crosswalk : Parallel line (paint)	Linear foot	$300
Crosswalk: Raised (speed table)	Linear foot	$2,500-$5,000
Crosswalk: Lighted flashing (in pavement flashers)	Per location	$100,000-$120,000
Crosswalk : Permeable paving (brick)	Square foot	$13-$15
Crosswalk : Stamped/colored concrete	Square foot	$10-$15
Grade separated crossing (pedestrian bridge)	Per location	$500,000-$4,000,000
Speed hump	Each	$3,000-$5,000
Refuge island	Per location	$10,000-$20,000
Pedestrian signal	Each	$40,000-$75,000
Crosswalk countdowns	Each	$2,000-$6,000
Pedestrian signs	Each	$250-$350
Curb extension	Per corner	$5,000-$10,000
Bulb-out	Per corner	$15,000-$25,000
Curb ramp	Per corner	$1,200
Orange safety flags at corner intersections (8 sets per intersection)	Per set	$100
Shared-Use Pedestrian and Bicycle Facilities	**Unit**	**Cost**
Shared-use path (10-foot width)*	Linear foot Linear mile	$133 $700,000
Side-path (10-foot width)*, or	Linear foot	$133
widen existing sidewalk to 8 feet for ped/bike use	Linear mile	$700,000

Crushed stone walkway (10-foot width)	Linear foot Linear mile	$15-$25 $80,000-$106 ,000
Wooden or recycled synthetic material boardwalk	Linear foot	$200-$250
(6-8 foot width)	Linear mile	$1,000,000-$1,300,000
Bicycle Facilities	**Unit**	**Cost**
Bike route signs	Per sign	$250-$350
Bicycle lanes (on existing pavement or during repaving)	Linear mile	$14,000
Restripe roadway for wide outside lanes	Linear mile	$14,000
Remove existing markings (lane removal or lane reduction/ road diet) and install bicycle lanes	Linear mile	$48,000
Install shared lane marking (on existing pavement or during repaving)	Linear mile	$8,000
Construct wide outside lanes (additional lane pavement added during roadway construction)	Linear mile	$300,000
Bicycle rack (purchase and install)	One rack	$600-$1,200
Bicycle locker (purchase and install)	One locker	$2,000
Amenities	**Unit**	**Cost**
Pedestrian-level street lights	Each	$3,000-$5,000
Standard street light (cobra head)	Each	$10,000

Reductions in Roadway Costs

Operating and maintenance costs include the costs associated with cleaning, repairing, and replacing infrastructure. Such costs include staff to clean and maintain sidewalks, repairing or replacing fixtures, repaving areas of paving, updating signage, and other regular maintenance activities. Data on operating costs are typically less easily obtained than capital cost improvements, although some costs can be obtained via government websites for operations and maintenance plans. Region-wide operating and maintenance estimates can be calculated by applying a unit cost obtained from government programs to a total mileage of sidewalk and bicycle inventory.

The Victoria Transport Policy Institute (VTPI) (2016) estimated that with roadway construction and maintenance costs averaging approximately 4 cents per mile for automobiles and heavier vehicles, "shifts from driving to walking or bicycling provide roadway facility and traffic service cost savings of approximately 5 cents per mile for urban driving and three cents per mile for rural driving, including indirect travel reductions leveraged by active transport improvements"(58). In addition, VTPI (2016) estimated that shifting from automobile to active travel could result in savings of $2-4 per urban-peak trip, $1-3 per urban off-peak trip, and about $1 per rural trip(58).

Recommendations for Utah Application:

- Use costs provided in current Utah specific reports to articulate infrastructure costs and benefits associated with active transportation.

2.7 Active Transportation as Economic Development

Adding active transportation infrastructure to a community is now an important component of an effective economic development strategy. This is particularly true for areas that want to attract and capitalize on latent demand for neighborhood environments that support active living and benefit an overall regional growth strategy. The level of adoption of major changes are almost universally limited in vehicular access impact. Yet business districts still often resist efforts to improve access for bicyclists, particularly if it means reallocating road space and parking historically utilized by cars(61). Shop owners tend to underestimate the amount of foot traffic arriving by active modes(62,63). Retailers also tend to resist the transition process of improving the infrastructure for active modes, overestimating the losses during construction of separated lanes(64).

Sources Reviewed:

- Modal Choices and Spending Patterns of Travelers to Downtown San Francisco: Impacts of Congestion Pricing on Retail Trade. (Bent & Singa, 2009)(62)
- The economic case for on-street bike parking. (Blue, 2011)(65)
- The Virginia Creeper Trail: An Assessment of User Demographics, Preferences, and The Virginia Creeper Trail: An Assessment of User Demographics, Preferences, and Economics. (Bowker, Bergstrom, & Gill, 2004)(66)
- The Great Allegheny Passage Economic Impact Study The Progress Fund's Trail Town Program. (Campos, 2009)(67)
- Consumer Behavior and Travel Choices: A Focus on Cyclists and Pedestrians. (Clifton et al, 2013)(68)
- Bicycling Means Better Business: The Economic Benefits of Bicycle Infrastructure. (League of American Cyclists & Alliance for Biking and Walking, 2012)(69)
- York Blvd - The Economics of a Road Diet. (McCormick & Affairs, 2012)(63)
- Analysis of economic impacts of the Northern Central Rail Trail. (Moore, 1994)(70)
- The Economic Benefits of Sustainable Streets. (New York Department of Transportation, 2013)(71)
- Bicyclists as Consumers: Mode Choice and Spending Behavior in Downtown Davis, California. (Popovich & Handy, 2014)(42)
- Bikenomics: Measuring the Economic Impact of Bicycle Facilities on Neighborhood Business Districts. (Rowe, 2013)(61)
- 300 South Progress Report: Broadway Protected Bike Lane. (Salt Lake City Division of Transportation, 2015)(72)
- Vancouver Separated Bike Lane Business Impact Study. (Stantec Consulting, 2011)(64)
- East Village Shoppers Study: A Snapshot of Travel and Spending Patterns of residents and Visitors in the East Village. (Transportation Alternatives, 2012)(73)

Key Metrics:

- Increased Foot Traffic
- Increased Tax Receipts

Several studies have evaluated the local economic effects of active transportation by analyzing revenue generated by businesses before and after implementing the infrastructure. For example, a recent study along York Boulevard in Los Angeles, CA documented increased sales tax revenues after a road diet reduced driving lanes and added bicycle lanes(63). Taxable retail sales data also increased in Seattle over 400% after installation of a bicycle facility(61). New York City DOT prepared a careful case-control analysis to show that better designed streets, including pedestrian and biking facilities, also improve the economic climate for businesses(71). Conversely, a study measuring the impacts of the instillation of a bike facility in Vancouver, Canada found that businesses in areas where the facility was installed suffered more significant losses than those outside of the affected areas(64).

According to the League of American Cyclists & Alliance for Biking and Walking (2012), the addition of temporary, painted-on bike lanes to an arts district in Memphis, Tennessee as part of a larger revitalization project resulted in 16 new businesses, 29 property renovations (17 at blighted locations), and 40,000 visitors to an area art event(69).

Installation of bike lanes and bike racks can have a positive influence on the local economy. Fort Worth, Texas spent $12,000 to purchase 80 bike racks and $160,000 on local road diets in one district in town. As a result, local restaurants experienced a 200% increase in business(65). Similarly, the Salt Lake City Division of Transportation (2015) found that removing 30% of on-street parking from 9 blocks on a major commercial street while improving crosswalks and sidewalks and adding protected bike lanes increased retail sales by 8.8% within six months, as compared with the 7% average increase experienced by the rest of the city(72).

Other studies have investigated the local economic effects of active transportation infrastructure in rural settings. The Virginia Department of Transportation (2004) estimated the total economic impact of spending by users of a rail trail in southwestern Virginia on the economies of two surrounding counties to be approximately 1.6 million, supporting close to 30 jobs (66). A study of the Great Allegheny Passage, a 132-mile system of biking and hiking trails connecting Cumberland, MD to McKeesport, PA found that, on average, one-quarter of gross revenue for local businesses was directly attributed to trail users, and two-thirds of local businesses reported that they experienced at least some increase in gross revenue because of their proximity to the trail (67). In addition, a study of the Northern Central Rail Trail in Maryland found that the Trail supports 264 jobs statewide(70). Table 16 lists studies addressing the local economic effects of active transportation infrastructure in rural settings.

Table 15: Studies Addressing Impact of Active Transportation Infrastructure Projects on Local Business Districts

Study	Location	Impact Area	Type of facility	Measurement	Outcome
Rowe (2013)	Seattle, WA	Retail streets/neighborhood districts	Two projects: Greenwood: loss of automobile travel lanes and 3 parking spots, and addition of two bicycle lanes Latona & 65th: loss of 12 parking spaces and installation of climbing lanes and sharrows	Retail sales data	Greenwood: No impact (project had 0 negative impact) Latona & 65th: 400% increase in taxable retail sales data after bicycle facility is installed
McCormick and Affairs (2012)	Los Angeles, CA	Impact of road diet on economic activity in surrounding community	Bike lane	Property sale price, Bradley-Burns sales tax, new business openings, business turnover, hedonic pricing model	Did not lower property values or degrade business performance - 80-95% of local businesses feel the bike lanes have not hurt their businesses

Stantec Consulting (2011)	Vancouver, CA	Business impacts of 2 separated bicycle lanes	Bike lanes	Retail sales data	Businesses in areas with bike lanes suffered more significant losses than those in areas without the bike lanes. Estimated total loss at $2.4 million/year
League of American Cyclists & Alliance for Biking and Walking (2012)	Memphis, TN	Retail streets/neighborhood districts	Temporary bike lanes	Revitalization of surrounding area	16 new businesses, 29 property renovations (17 at blighted locations), and 40,000 visitors to an area art event
Blue (2011)	Forth Worth, TX	Retail/service industry impacts	$12,000 to purchase 80 bike racks and $160,000 on local road diets in one district in town	Sales data	Local restaurants reported 200% increase in business
Salt Lake City Division of Transportation (2015)	Salt Lake City, UT	Retail streets/neighborhood districts	removing 30% of on-street parking from 9 blocks on a major commercial street while improving crosswalks and sidewalks and adding protected bike lanes	Sales data	Increased retail sales by 8.8% within six months, as compared with the 7% average increase experienced by the rest of the city

Table 16: Studies Addressing Impact of Active Transportation Infrastructure in Rural Settings

Study	Location	Impact Area	Type of facility	Measurement	Outcome
Bowker, Bergstrom, & Gill (2004)	Washington and Grayson Counties, VA	Trails/Tourism	34-mile multi-use rail trail	Trail user spending	Aggregated across the estimated 100,870 trips per year to an estimated range of $2.3-$3.9 million in net economic benefits to VCT users
Campos (2009)(67)	Cumberland, MD & McKeesport, PA	Trails/Tourism	132-mile system of biking and hiking trails	Trail user spending	$23,878,495 worth of receipts (actual revenue) was attributed to the trail ($11,990,990 in 2007 and $11,887,505 in 2008) and $4,372,190 worth of wages
Moore (1994)[47]	Maryland	Trails/Tourism	20-mile multi-use rail trail	Trail user spending	NCRT supports 264 jobs statewide. The value of goods purchased because of the NCRT for 1993 is estimated to total in excess of $3,380,000 in 1993

In addition, various studies have confirmed that pedestrians and cyclists spend as much, if not more, than those traveling by car. The literature shows that pedestrians and bicyclists make more frequent purchases than car-driving counterparts(42,62,68,73). The evidence for amount spent per shopping trip is more mixed, but still favors active modes. Popovich and Handy's (2014) recent study in Davis, California also suggested that cyclists spent more than their automobile counterparts(42). A neighborhood survey of the East Village in New York City also indicates that bicyclists may spend more than those arriving by car; in the case of East Village, over 95% of retail dollars came from active or transit modes(73). Clifton et al.'s (2012) study of bicyclists in Portland found that bicyclists spent more than those who arrived by automobile in the downtown core (68). While at first glance this finding did not translate to other neighborhoods, once the frequency of trips was accounted for, bicyclists spent more than car passengers. Table 17 provides studies estimating the varying economic impacts of consumers by modal choice on local business districts.

Table 17: Studies Addressing Impact on Local Business Districts by Modal Share

Study	Location	Impact Area	Type of facility	Measurement	Outcome
Bent & Singa (2009)(62)	San Francisco, CA	Comparison of spending and modal share	By mode – transit, walking, drivers, and carpoolers	Spending and frequency of visits	Transit riders made up 60% of modal share, spent $40 per visit, and visited 7 days/month. Walkers made up 21% of modal share, spent $27 per visit, visited 8 days/month Drivers made up 16% of modal share, spent $88 per visit, visited 4 days/month
Clifton et al (2013)[42]	Portland, OR	Business impacts by modal choice	Mode	Amount sent per trip, frequency of visits by mode	In terms of mode of access, only walking was significantly associated with spending – customers who walk to the bar or restaurant are likely to spend $3.54 more than those using other modes.Cyclists spend the most per month at drinking places, almost $82, despite spending the least per trip, just under $17 on average due to greater frequency of visits – 5 times per month
Popovich & Handy (2014)[41]	New York, New York	Business impacts of bike lanes and public transit in East Village	Bike lanes, transit infrastructure	Bike and pedestrian spending vs. cars and # of visits per week	Bicyclists and pedestrians spend more on average per week $163 and $158, respectively) than those arriving by car ($143) Almost 2/3 of pedestrians and bicyclists visited 5 or more times per week, while only 44% of drivers visited more than 5 times a week

Next Steps in Reviewing Methods for Utah Application:

- Previous studies show that increasing active travel facilities can serve as an economic driver for small business districts. Calculating the effects, however, requires additional survey work which could be included in future phases of this study.

2.8 Migration

Aside from tourism, an area's active transportation and recreation infrastructure have also been shown to attract individuals and businesses looking to relocate.

Sources Reviewed:

- Taking up cycling after residential relocation: Built environment factors. (Beenackers et al., 2012)(74)
- The influence of urban design on neighborhood walking following residential relocation: Longitudinal results from the RESIDE study. (Giles-Corti et al., 2013)(75)
- Enhancing Rural Community Assets through Active Transportation Planning: A Case Study of Norway, Maine. A thesis submitted by Kristine Keeney. (Keeney & Chase, 2015)(76)
- Natural Amenities and Population Growth in the Greater. (Rasker & Hansen, 2000)(77)
- Entrepreneurial Migration. (Transportation for America, 2015)(78)

Key Metrics:

- Priority of transportation facilities in retiree decisions
- Priority of recreational facilities in retiree decisions
- Any estimates should address in-state versus out-of-state migration

Despite the attraction of urban areas to working age adults, various aspects of rural areas have been found to stimulate population growth and attract business opportunities. Rasker and Hansen (2000) investigated whether ecological or amenity variables explain variation in population growth in comparison to that of social or economic variables and found that amenities, such as varied topography, mountains, and recreational facilities play a significant role in attracting people and businesses(77). Snepenger, Johnson, and Rasker (1995) surveyed native and out-of-state businesses ("travel-entrepreneurs") in Montana to investigate what attracted those businesses to locate in the area(79). The importance of recreational opportunity was found to be consistent across business types.

Due to the significant anticipated growth of the aging population, access to recreational and transportation facilities is also a growing need in suburban and rural areas. Using data gathered by American Association of Retired Persons (AARP), Transportation for America (2015) found older adults are unlikely to move after age 55 and value remaining in their current residences for the remainder of their lives(78). Because many older adults lose their ability to drive and thus become increasingly reliant on public transportation and safe transportation facilities, active transportation infrastructure plays a more important role in aging in place(78).

Efforts to improve transportation facilities to be supportive of active transportation options can be instrumental in economically revitalizing rural communities(76). Keeney's (2015) case study of a rural town in Maine demonstrated how small enhancements to a rural community's transportation infrastructure, such as repairing existing sidewalk facilities and striping on-street bicycle facilities, could be harnessed to achieve those potential economic benefits(76).

To explore the association between migration and use of active and recreational facilities, two studies used data from RESIDential Environmental Project (RESIDE), longitudinal natural experiment of people moving into new housing developments in Perth, Australia (74,75). Giles-

Corti et al (2013) found that, on average, minutes of walking among adults following relocation to a new, lower density neighborhood decreased significantly for transportation and increased significantly for recreation[46]. With respect to bicycling, Beenackers et al (2012) found that greater residential density, increased access to parks, and more recreation-related destinations were positively associated with increased transportation-related bicycling, whereas an increase in connectivity was associated with the uptake of recreational bicycling(74).

Next Steps in Reviewing Methods for Utah Application:

- There is insufficient evidence to integrate migration patterns attributable to active transportation in future phases of this study.

2.9 Use of Input-Output Modeling

Economic models known as Input-Output modeling predict indirect and induced effects of active transportation investments. Input-output models are used to understand how active transportation infrastructure spending ripples through the economy in terms of consumption and employment. This type of economic modeling is included within Phase II of this project.

Sources Reviewed:

- An Economic Impact Study of Bicycling in Arizona: Out-of-State Bicycle Tourists & Exports. (Arizona Department of Transportation, 2013)(8)
- The Virginia Creeper Trail: An Assessment of User Demographics, Preferences, and The Virginia Creeper Trail: An Assessment of User Demographics, Preferences, and Economics. (Bowker et al., 2004)(66)
- The Economic Impacts of Active Transportation in New Jersey. (Brown & Hawkins, 2013)(2)
- Pedestrian and Bicycle Infrastructure: A National Study of Employment Impacts. Garrett-Peltier, 2011)(80)
- Valuing Bicycling's Economic and Health Impacts in Wisconsin. (Grabow et al., 2010)(10)
- Economic Impact Analysis of Orange County Trails. (East Central Florida Regional Planning Council, 2011)(81)
- Economic Impact of Bicycling and Walking in Vermont. (Vermont Agency on Transportation, 2012)(4)

Key Metrics:

- Types of I-O Models employed
- Indirect, Induced multipliers for jobs and economic output

A national study of employment impacts from bicycle and pedestrian infrastructure estimated an average employment impact of building and refurbishing transportation infrastructure for cyclists and pedestrians using detailed cost data gathered through survey research in eleven cities. On average, this study found that $1 million in bicycle projects create 11.4 jobs from direct, indirect and induced construction spending. Likewise, pedestrian-only projects create about 10 jobs and multi-use projects create 9.6 jobs per $1 million of project cost. Projects that combine pedestrian and bicycle facilities with road improvements create 7.8 jobs per $1 million. Road only projects generated 7.75 jobs per $1 million. Spillover (indirect) employment adds an additional 3 jobs per $1 million(80).

Table 18: Job Creation: Infrastructure – Construction and Maintenance [1]

Project Type	Jobs created per $1million direct, indirect and induced construction spending	Spillover (indirect) employment
Bicycling	11.4	3
Walking	10	
Multi-use	9.6	
Bicycle, Walking, Road	7.8	
Road	7.6	

Economic studies of active transportation that use input-output modeling vary in the specific models used. For example, two studies utilized REMI[7] to calculate the economic outputs of active transportation(4,81). This economic input/output model is an accounting method used to describe a specific regional economy and has the ability to trace small changes in one part of the economy throughout the entire regional economy (4). The East Central Florida Regional Planning Council analyzed the spending impact related to three Orange County trails on the local economy of Downtown Winter Garden using survey data related to consumer spending habits and business sales(81). Inputs of approximately $32.6 million in expenditures by trail users translated into an estimated $42.6 million in output/retail sales, as well as $10 million in personal income and 516 jobs(81). Similarly, the Vermont Agency on Transportation used a REMI model to assess the overall economic impacts of active transportation at the state level. Using inputs including bicyclist and pedestrian facility capital investment, related businesses and visitor spending related to bike/ped, the REMI model showed an estimated output of $6.2 million, supporting a total of 160 jobs(4).

Three studies used IMPLAN[8], an Input-Output model built primarily from U.S. Bureau of Economic Analysis (BEA) data along with additional data sources. While each of the three studies addressed different impact areas, as well as different geographies, each of them found significant economic benefits from active transportation-related infrastructure investments and/or use. Using inputs including daily resident and non-resident spending on various types of active transportation-related tourism, Grabow et al (2010) estimated that Wisconsin experienced $9.24 million in total economic benefit(10). Similarly, Bowker et al (2004) utilized input data on visitor spending per trip for the Virginia Creeper Trail in southern Virginia, producing an estimated $2.3-3.9 million in net economic benefits for trail users(66). At the national level, Garrett-Peltier (2011) used an IMPLAN model to estimate that, on average, an input of $1 million in active transportation infrastructure projects produces 9 jobs within the state of each project(80).

Other studies examining active transportation have been completed using other input-output models. A 2012 study examining the economic impacts of walking and bicycling in New Jersey which was performed using the R/ECON model, estimated an impact of nearly $500 million, over 4,000 jobs, and about $31 million in state and local tax revenue in 2011(2). This study included survey-based inputs in three areas: active transportation infrastructure expenditures from governments, revenue and employment estimates from active transportation-related businesses, and expenditures by participants in active transportation-related events. In Arizona, an examination of the economic impacts of bicycling used bicycle industry data and surveys on

[7] http://www.remi.com/the-remi-model

[8] http://www.implan.com/

establishments, sales and employment as well as surveys of bicycle event participants(8). This study used the Regional Dynamics Model (Redyn Model[9]) to estimate total economic impact of just

Table 19: Studies using I-O Modeling

Study	Location	Impact Area	Model	Outcome
Arizona Department of Transportation (2013)(8)	Arizona	Retail sales, tourism, events	REDYN	Estimated 721 jobs in bike tourism and retail and manufacturing; $88,170,000 indirect (output); $32,002,000 induced (disposable income); $31,190,000 direct (labor income) resulting from an estimated 14,000 out-of-state participants (tourists) attending approximately 250 events throughout the state in 2013
Vermont Agency on Transportation (2012)(4)	Vermont	Infrastructure, Retail Sales, Tourism, Events, Trails	REMI	Tourism- 40 major running and bicycling events taking place across VT in 2009 = 16,000+ participants that spent $6.2 million related to major bicycling and running events support a total of 160 jobs (123 direct and 37 indirect)
East Central Florida Regional Planning Council (2011)(81)	Orange County, FL	Retail sales	REMI	Total estimated expenditure by trail users of $32.556 million (2010$). Supports 516 jobs, $42.6 million in output/sales, $10 million in personal income.
Brown & Hawkins (2013)(2)	New Jersey	Infrastructure, Retail Sales, Events	R/ECON	Investments of $63.17 million in infrastructure estimated to generate $149.63 million in total economic activity - 648 jobs, approx. $44.57 million in wages and salary income, $15.68 million in tax revenue, and contributions of $75.62 to GDP of NJ.
Grabow et al (2010)(10)	Wisconsin	Tourism	IMPLAN	Direct economic impact resulting from 12,993,647 days of bicycle recreation (roadways, trails, single-day bike events/tours, multi-day tours) in WI totals $532,883,557.
Bowker et al (2004)(66)	Washington & Grayson Counties, VA	Trails and Tourism	IMPLAN	Net economic benefit to users of the VCT is between $23 and $28 per person per trip. Aggregated across the estimated 100,870 trips per year to an estimated range of $2.3-$3.9 million in net economic benefits to VCT users
Garrett-Peltier (2011)(80)	U.S.	Infrastructure	IMPLAN	$1 million in cycle projects construction = 11.4 jobs from direct, indirect and induced. $1 million in pedestrian only projects construction= about 10 jobs. $1 million in multi-use projects = 9.6 jobs. Projects that combine pedestrian and cycle facilities with road improvements create 7.8 jobs per $1 million. Road only projects generated 7.75 jobs per $1 million. Spillover (indirect) employment adds an additional 3 jobs per $1 million

over $13 million and just over 400 jobs across the state. This study differs from the New Jersey study in that it focuses on bicycling and related activities that include bicycling, such as triathlons, and that it did not include capital expenditures that enable or support bicycling and bicycle-including activities.

Next Steps in Reviewing Methods for Utah Application:

- As part of Phase II of this project, develop economic input-output model (e.g.,

[9] http://www.redyn.com/

IMPLAN[10]) to assess overall impact of expenditures and employment (i.e., direct, indirect, and induced economic impacts).

[10] http://www.implan.com/

3 Environment -- Active Transportation and Emissions

A significant environmental impact of walking and bicycling is due to the resulting reduced use of motorized vehicles. Reduced driving means cleaner air from reductions in the burning of fossil fuels.

Sources Reviewed:

- Climate Change and Bicycling: How bicycling advocates can help craft comprehensive Climate Action Plans. (Advocacy Advance Project, 2011)(82)
- Guide to Cap-and-Trade Programs (League of California Cities, 2016)(83)
- Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions. (Cambridge Systematics, 2009)(84)
- GHG Equivalencies Calculator - Calculations and References. (Environmental Protection Agency, 2016)(85)
- Sample Calculation of Emission Reductions and Fuel Savings from a Carpool Program - Emission Facts (EPA-420-F-08-028). (Environmental Protection Agency, 2008)(86)
- The Case for Active Transportation. (Oregon Metro, 2009)(87)

Key Metrics:

- Reductions in vehicle miles traveled (VMT (see Section 2.4)
- Reductions in GHG, PM2.5, and/or Ozone from Reduced VMT (see Section 4.3 for application to health)

Research indicates that combined pedestrian and bicycle infrastructure and policies applied nationally would result in a cumulative 0.2% to 0.5% reduction (including non-surface transportation emissions) in baseline emissions(84). Using active transportation as an environmental lever results in a relatively low implementation cost, and with positive public health benefits(84). The Rails to Trails Conservancy estimates that bicycling and pedestrian travel can offset between 3% and 8% of GHG emissions in the United States caused by surface transportation(87).

Many state applications for Congestion Mitigation and Air Quality Improvement Program (CMAQ), a federal funding program, ask applicants to estimate the congestion and GHG reduction potential of their bicycle and pedestrian projects. A federal review of CMAQ bicycle and pedestrian projects found CO_2 reductions of up to 38.4 kg emissions reductions each day(82). They note that these projects are "more effective when designed to enhance access to transit, so that longer trip lengths may be reduced"(82).

California has established a cap-and-trade program to reduce the greenhouse gas (GHG) emissions that cause climate change. Implementation of this program involves the establishment of an overall limit on GHG emissions from capped sectors. Polluting facilities subject to the cap are able to trade permits (allowances) to emit GHGs. In California Governor Jerry Brown's proposed FY 2016-17 budget $3.1 billion from Cap and-Trade auction proceeds are allocated, including $100 million for the Department of Transportation to administer the Low Carbon Road Program. This program will that encourage active transportation, such as walking and bicycling, transit, and other carbon-reducing road investments by providing funding for improvements to local streets and roads(83).

State-level greenhouse gas legislation is increasingly requiring transportation modelers to estimate gains by active transportation levers. For example, every 1% increase in miles traveled by active transportation instead of by car reduces the Portland region's greenhouse gas emissions by 0.4% (87). The Los Angeles Metropolitan Transportation Authority found that bicycle-rail trips replace approximately 322,000 motor vehicle trips, reducing 3.96 million VMT annually, offsetting approximately 422 motor metric tons of carbon dioxide equivalents annually(44).

The US EPA's on-road mobile source emissions model MOVES[11] is used for regulatory purposes under the Clean Air Act. It provides a detailed, comprehensive tool to estimate average emissions per mile and per start. These rates can be applied to changes in vehicle miles traveled and trips to calculate the changes in emissions. Other simpler calculators (requiring less detailed inputs) and look-up tables are also available to provide estimates of changes in emissions from reductions in miles driven. For example, the US EPA's finds that every mile driven by cars and light trucks produces 4.20 x 10-4 metric tons carbon dioxide equivalents(85)[12], and 0.0041 g/mi of $PM_{2.5.}$(86).

Next Steps in Reviewing Methods for Utah Application:

- Estimate emissions changes due to walking and bicycling by applying US EPA factors to estimated distances traveled, while accounting for assumption that not every walk/bicycle trip would otherwise be done by a motor vehicle.

11 https://www3.epa.gov/otaq/models/moves/

12 Based on – "In 2011, the weighted average combined fuel economy of cars and light trucks combined was 21.4 miles per gallon (FHWA 2013). In 2011, the ratio of carbon dioxide emissions to total greenhouse gas emissions (including carbon dioxide, methane, and nitrous oxide, all expressed as carbon dioxide equivalents) for passenger vehicles was 0.988 (EPA 2013a, EPA 2013b)."

4 Health Benefits

The Utah Collaborative Active Transportation Study affirmed that active forms of transportation, including walking and bicycling, provide individuals with a low-cost, accessible option to engage in daily physical activity(43). Physical activity results in reduced body-mass index (88,89) and in reduced risk of chronic diseases such as diabetes, stroke, and heart disease (90). This section focuses on these physical activity-based health gains. However, active transportation also results in more indirect health effects from reduced VMT and congestion: air quality driven health effects (covered in the previous section) and increased traffic safety. Reduction of illness or injury from all these pathways leads to reduced mortality, a reduction in direct healthcare expenditures, and an increase in productivity.

This section begins by exploring the state of the literature in addressing mortality versus morbidity. It then addresses physical-activity focused examples of monetizing health from active transportation. It also briefly discusses air quality examples.

4.1 Monetizing Mortality versus Morbidity

This section defines key concepts driving current monetization of public health benefit methodologies. This includes background information about monetizing mortality through value of statistical life (VSL), monetizing morbidity by leveraging cost of illness (COI) studies, and modeling considerations required to combine them.

Sources Reviewed:

- The Benefits Of Bicycling In Minnesota. (Barnes, 2004)(91)
- The Economic Impact of Bicycling in Wisconsin. (Bicycle Federation of Wisconsin, 2006)(6)
- The economic benefits of reducing physical inactivity: an Australian example. (Cadilhac et al., 2011)(92)
- Benefit-Cost Analysis of Public Health Outcomes in Long Range Transportation Planning in the San Francisco Bay Area. (Co & Vautin, 2014)(93)
- Estimating the health economic benefits of cycling. (Deenihan & Caulfield, 2014)(94)
- Costs and benefits of bicycling investments in Portland, Oregon. (Gotschi, 2011)(95)
- Valuing Bicycling's Economic and Health Impacts in Wisconsin. (Grabow et al., 2010)(10)
- Climate Smart Strategy: Health Impact Assessment. (Iroz-Elardo et al., 2014)(96)
- Health Economic Assessment Tools (HEAT) for walking and for cycling economic assessment of transport infrastructure. (Kahlmeier et al., 2011)(97)
- Phase I Final Report: Community and Economic Benefits of Bicycling in Michigan. (Michigan Department of Transportation, 2014)(98)
- Safer Streets, Stronger Economies: Complete Streets project outcomes from across the country. (Smart Growth America, 2015)(57)
- Economic impact of reduced mortality due to increased cycling. (Rutter et al., 2013)(99)
- Economic & Health Benefits of Bicycling in Iowa. (University of Northern Iowa, 2011)(5)

Key Metrics:

- Models morbidity versus mortality

Methodologies to monetize public health gains from transportation are fairly developed for mortality, or prevention of premature death. Mortality is monetized by applying well-established value of statistical life (VSL) to each prevented death. Although VSL implies that each life is worth a particular value, VSL is the aggregation of many individuals' willingness-to-pay (WTP) for a small reduction in risk. The estimation of willingness-to-pay for reduced mortality risk is generally obtained through one of three methodologies: hedonic modeling, averting behavior models, and stated preference (also known as contingent valuation). The U.S. DOT provides monetization guidance developed for fatalities with a discounted rate to be applied to serious injuries(100); U.S. EPA also provides (slightly lower) VSL guidance(101).

The most prominent example of mortality-based monetization in active transportation is the World Health Organization's Health Economic Assessment Tool (HEAT)(97). HEAT applies VSL (user defined) to estimates of avoided all-cause mortality. Examples of studies using HEAT include new bike facilities in Ireland(94), comparisons of bicycling rates in three U.S. cities(99), assumptions about walking in Portland, Oregon(102).

There are known issues in the VSL literature. Notably, average VSL has increased in a non-linear fashion over the past few decades, out-pacing inflation and other economic indicators; this is likely due to modern trends of less tolerance for risk. VSL can vary by income group, age, and even race or union status; as commonly reported VSL represents an average-aged adult earning an average wage. VSL varies by country due primarily to differences in income and standard of living, but also reflective of variation in social norms. It is also important to note that VSL is not representative of actual money circulating in the economy – a challenge in the context of monetizing active transportation to justify return on investment. Instead, VSL represents a valuation based on the amount an average person would pay for reduced risk. Thus a limitation of mortality-based monetization is the inability to capture health care cost savings; researchers studying physical activity recognize a need to monetize associated morbidity (illness) outcomes(92,103–105).

Table 20: Studies Monetizing Public Health, Topics, and Approach to Mortality and/or Morbidity

Citation	Tool Used?	Mortality	Morbidity – Healthcare Expenditures	Morbidity - Productivity	Physical Activity	Air Quality
Iroz-Elardo, et al (2014)(96)	ITHIM	X	X	X	X	X
Rutter, et al (2013)(99)	HEAT	X			X	
Cadilhac et al (2011)(92)					X	
Co & Vautin (2014)(93)			X	X	X	
University of Northern Iowa (2011)(106)			X		X	
Michigan Department of Transportation (2014)(98)			X	X	X	
Gotschi (2011)(95)	HEAT	X			X	
Smart Growth America (2015)(57)		X	X			
Grabow et al (2010)(10)			X	X	X	X
Bicycle Federation of Wisconsin (2006)(6)					X	
Barnes (2004)(91)				X	X	
Kahlmeier et al (2011)(97)	HEAT	X			X	
Deenihan & Caulfield (2014)(94)	HEAT	X			X	

Studies that monetize the health benefits of active transportation generally use a Comparative Risk Assessment approach where (1) the difference between expected rates of disease with and without physical activity are modeled and (2) multiplied by cost of illness (COI) for the disease or risk factor derived from econometric analyses. COI methodology dates back to the 1960's and continues to be used to describe healthcare expenditures at the macro level. It is useful in a policy context to describe the magnitude of the current problem and the anticipated benefit should a reduction in disease occur. COI incorporates both direct and indirect costs associated with a disease. Direct costs, or health care expenditures, are considered money exchanged for health care, pharmaceuticals, and therapy. Indirect costs, in the field of economics, are associated with lost productivity and absenteeism.

COI is reported as both "per case" and national aggregate annual costs with the assumption that the cost is applied in the year that it occurs even as the literature acknowledges that individuals accrue additional costs over time. This prevalence-based approach marries with epidemiological evidence and distribution of disease. The number of prevented cases from health modeling is multiplied by the per-case annual savings for total health savings. COI studies that will likely be applied in the Utah project are provided in Table 19 below.

Table 21: Studies monetizing morbidity by health endpoint

Health Outcome	**Annual Per Case (2016$)**	
	Direct	**Indirect**
Diabetes	$7,124[1](107,108)	$2,734[1](107)
Hypertension	$581(108)	$46(108)
Heart Disease	$4,222(108)	$3,823(108)
Obese (BMI 30.0 or higher)	$3,815(109)	$287[1](110)
Asthma	$2,296(111)	$722(111)
COPD	$710(112)	$581(112)

[1]Utah-specific estimate

Next Steps in Reviewing Methods for Utah Application:

- Keep mortality and morbidity "benefits" separate because COI is money circulating in the economy and VSL is a valuation.
- Prioritize modeling morbidity in order to have an estimate of direct healthcare expenditure costs and indirect productivity costs.
- Consider modeling mortality (premature death) and monetize using VSL. Investigate using cause-specific mortality relative risks to support this portion of the modeling.

4.2 Physical Activity Health Impacts

This section reviews regional monetization studies specific to active transportation and physical activity

Sources Reviewed:

- Benefit-Cost Analysis of Public Health Outcomes in Long Range Transportation Planning in the San Francisco Bay Area. (Co & Vautin, 2014)(93)
- Valuing bicycling's economic and health impacts in Wisconsin. (Grabow et al., 2010)(10)
- Economic and health benefits of bicycling in Iowa. (University of Northern Iowa, 2011)(5)
- Costs and benefits of bicycling investments in Portland, OR. (Gotschi, 2011)(95)
- Climate Smart Strategy Health Impact Assessment in Portland, OR. (Iroz-Elardo et al., 2014)(96)
- Community and economic benefits of bicycling in Michigan, Phase 1 report. (Michigan Department of Transportation, 2014)(98)

Key Metrics:

- Minutes of active transportation
- Prevalence rates of health risk factors (BMI/obesity) and outcomes (hypertension, cardiovascular disease, and diabetes)

The health benefits of active transportation are numerous. The Center for Advancing Health found that communities with higher rates of bicycling and walking had lower obesity rates than communities with lower levels of active transportation(113). Even small amounts of physical activity can significantly impact health outcomes. For example, researchers from Harvard University found that bicycling for as little as 5 minutes each day can prevent weight gain for middle aged women(114).

We examined the methodological approaches and findings from the six studies listed above that monetized public health savings from active transportation. Each of those studies estimated public health savings from reductions in morbidity attributable to increased physical activity from active transportation, and two studies also estimated public health savings from reductions in mortality(95,96). Table 20 demonstrates the variety of morbidity health endpoints related to physical activity that were addressed by the reviewed studies.

Table 22: Studies monetizing morbidity from active transportation by health endpoint

Citation	Obesity	Cardiovascular Disease	Diabetes	Hypertension	Stroke	Breast Cancer	Colorectal Cancer	Respiratory Disease
Iroz-Elardo, et al (2014)(96)		X	X	X	X			X
Co & Vautin (2014)(93)	X	X	X	X	X			
Gotschi (2011)(95)		X	X	X			X	
University of Northern Iowa (2011)(106)		X	X		X	X		
Michigan Department of Transportation (2014)(98)		X			X			
Grabow et al (2010)(10)		X	X	X	X	X	X	X
Guo & Gandavarapu (2010)(56)	X							

Table 23: Studies monetizing morbidity from physical activity

Study	Location	Morbidity(ies)	Measurement	Outcome
Iroz-Elardo, et al (2014)(96)	Portland, OR	Cardiovascular disease, diabetes hypertension, stroke	Reduction in illness of 1.3% linked to physical activity increasing by 0.5 miles of walking and 1.3 miles of biking per week.	Draft approach estimated in both direct and indirect cost savings of: $64 million/year in cardiovascular and stroke savings, $26 million in diabetes savings, $5.5 in cancer savings
Co & Vautin (2014)(93)	San Francisco, CA	Obesity, cardiovascular disease, diabetes, hypertension, stroke	Morbidity (health care): COI of $326/yr for physically inactive person (*The Economic Costs of Overweight, Obesity and Physical Inactivity Among California Adults*, California Center for Public Health Advocacy, 2006.) Morbidity (absenteeism): $717/year for physical inactivity	Bay Area residents could achieve $1.1 billion ($344 million in health care and $756 million in lost productivity) savings if 70% growth in active transportation was met.
Gotschi (2011)(95)	Portland, OR	Cardiovascular disease, diabetes, hypertension, colorectal cancer	Morbidity: Average COI for inactivity from three studies is $544 per person (2008$) Mortality: VSL from USDOT	By 2040, investments in the range of $138-605 million will result in: Health care cost savings: $388-594 million and savings in value of statistical lives of $7-12 billion. Benefit-cost ratios for health care and fuel savings: between 3.8 and 1.2 to 1, and an order of magnitude higher when value of statistical lives is used.
University of Northern Iowa (2011)(106)	Iowa	Cardiovascular disease, diabetes, stroke, breast cancer	Morbidity: COI – 20th and 80th percentile for cost of treatment from Blue Cross Blue Shield; Median health care costs ~ $1002 per person per year for all 5 diseases.	Median health care savings from commuter cyclists: $53,826,145 Median savings for recreational riders: $300,019,590
Michigan Department of Transportation (2014)(98)	Michigan	Cardiovascular disease, stroke	Morbidity (health care): COI of $466/yr for physically inactive person (Michigan Department of Community Health) Morbidity (absenteeism): $341/day and assumes bike commuters miss 1 less day per year.	Avoided health care costs: $256 million Reduced absenteeism: $187 million
Grabow et al (2010)(10)	Wisconsin	Obesity, cardiovascular disease, diabetes, hypertension, stroke, breast cancer, colorectal cancer	Morbidity - COI averages out to $285 for every Madison resident and $309 for every Milwaukee resident who moves from physically inactive to active.	Total potential value of health benefits from reducing short car trips and increasing bicycle trips: $320 billion.

All of the reviewed studies used cost of illness, usually translated into cost per case to apply to the number of reduced cases of physical inactivity or disease. Some of the studies were less than transparent about the source of the costs, and most reported a lump sum at the end rather than a per capita cost savings. With a few assumptions about the population in a state or metropolitan statistical area (MSA), however, the per capita costs savings could be calculated. The per capita cost associated with active transportation physical activity ranged from $285 in reduced health care costs from diabetes, heart disease, breast cancer, colorectal cancer, and stroke in Madison, Wisconsin(10) to $1002 per year in Iowa(5) using Blue Cross Blue Shield median cost of treatments for the same five disease endpoints. All of the reviewed studies monetized reductions in cardiovascular disease, diabetes, and stroke. Obesity was addressed as a risk factor for morbidity associated with physical inactivity in one study(93). Moreover, three studies estimated cost savings associated with breast and colorectal cancer

A significant theme thus far in these studies is leveraging physical inactivity as the health "endpoint"(5,10,93,95,98). Moving from insufficiently to sufficiently active – defined as 150 minutes of moderate activity a week as recommended by the U.S. Department of Health and Human Services *Physical Activity Guidelines* (2008) – was then translated into the proportion of cardiovascular, diabetes, and cancer outcomes. Active transportation levels were usually drawn from either surveillance systems such as Behavioral Risk Factor Surveillance System (BRFSS) or the National Household Travel Survey (NHTS) or from travel demand modeling. For example, some studies assumed that anyone who currently bicycled would not meet the sufficiently active threshold without that active transportation(5,98); assumed that all physically inactive individuals would become physically active(10) and using travel demand modeling and/or regional plan assumptions about infrastructure change(93,95).

Next Steps in Reviewing Methods for Utah Application:

- Model morbidity-specific endpoints for diabetes, hypertension, and heart disease from physical activity minutes of active travel. Apply morbidity COI in section 4.1.

4.3 Air Quality Health Impacts

This section reviews regional monetization studies specific to active transportation and air quality.

Sources Reviewed:

- Climate Smart Strategy Health Impact Assessment in Portland, OR (Iroz-Elardo et al., 2014)(96)
- An economic evaluation of health-promotive built environment changes. (Guo & Gandavarapu, 2010)(56)
- Valuing bicycling's economic and health impacts in Wisconsin (Grabow et al., 2010)(10)

Key Metrics:

- Changes in regional ambient air averages and number of days above standards for PM2.5 and ozone
- Morbidity for asthma and chronic obstructive pulmonary disease (COPD)

Air quality is an important co-benefit of active travel. Three studies reviewed claimed to address health impacts of air pollution; however only Iroz-Elardo et al (2014)(96) and Grabow et al (2010)(10) appear to directly calculate health impacts of air pollution13. These two studies first

13 While Guo & Gandavarapu(56) suggest they estimate health impacts from air quality, they multiply VMT reductions by an average unit cost of vehicle-

modeled changes in specific pollutants and then modeled greater reductions in respiratory disease, such as asthma, chronic obstructive pulmonary disease (COPD), and emergency room visits due to respiratory symptoms as well reductions in cardiovascular disease. Iroz-Elardo et al (2014) pivoted from air quality modeling that suggested that a 23.1 mile per week reduction in VMT in the Portland metro area would reduce fine particulate matter by 17.1%. The associated respiratory and cardiovascular illness reduction was 2.5%; the reduction in VMT was also expected to prevent approximately 59 deaths per year (96). Grabow et al (2010) estimated that a 20% reduction in VMT in Milwaukee and Madison, WI would result in respiratory disease reductions equivalent to $1.58 million(10).

Table 24: Studies monetizing morbidity from air quality

Study	Location	Morbidity(ies)	Scenario	Outcome
Iroz-Elardo et al (2014)(96)	Portland, OR	Respiratory disease (asthma/COPD) and cardiovascular	PM2.5 reductions due to VMT reduction of 23.1 miles per week, resulting in 17.1% reduction in PM2.5.	Lower per capita VMT combined with technological advances in fuels suggests that illness linked with air quality as measured by fine particulate matter (PM2.5) will improve by at least 2.5% and prevent 59 premature deaths each year
Grabow et al (2010)(10)	Wisconsin	Asthma, chronic bronchitis, respiratory symptoms (hospital admissions & ER visits)	PM2.5 and O3 reductions due to 20% reduction in VMT	Using BenMAP, calculated health and economic benefits of reducing 20% of urban and suburban car trips (<8km) in Milwaukee and Madison and determined the associated reduction in PM 2.5 and ozone: Morbidity $1.58 million
Guo & Gandavarapu(2010)(56)	Wisconsin (Dane County)	Unclear	Complete the sidewalk network	$8.23million in air pollution benefits. Note this was modeled straight from VMT and thus health portion is unclear.

Next Steps in Reviewing Methods for Utah Application:

- Model morbidity-specific endpoints for asthma and COPD using relative risks from ozone and PM2.5 reductions. Apply morbidity COI in section 4.1.

mile air pollution sourced elsewhere. The VMT reduction factor is supposed to account for health in addition to climate; the extent to which the factor(s) used are attributable to specific health endpoints, morbidity versus disease, and the relative contribution of climate is unclear.

5 Conclusions and Next Steps

This review of studies provides a summary of the state of the practice of methods, data and findings related to the benefits and impacts of active transportation. This is a broadly scoped review and taken collectively, there are many findings that form the basis of a broad-based approach to building a well-founded Active Transportation Strategy for Utah. The evidence that was reviewed and synthesized in many areas was extensive – over 100 studies across multiple disciplines and domains. Research in a few areas of impact is still developing and not much evidence yet exists. Going forward, it will be possible to focus on the way in which certain areas connect and help other areas of investment and improvement. This focus will help prioritize these synergistic win-win areas.

Each section concluded with next steps for this Utah study. These conclusions and next steps will be used for to inform the local data collection effort (Task 3.3). In doing so, information and data will be prioritized in the following manner:

- The quantification of the benefits in Utah will first be done using local data when available.
- When needed, local data will be supplemented with findings from the studies conducted elsewhere including those reviewed here. In limited instances, similar studies brought forward in the next steps of the study may be used.

The benefits will initially be reported, using available data, as part of Task 3.2 *Current Conditions Reports* at the state, regional and county levels (Task 3.4). In the, yet to be funded, Phase 2 Task 4 *Benefits Analysis* effort, the direct impacts will be more completely analyzed and supplemented with estimates of indirect and induced economics impacts using an econometric input/output model. Areas where additional research is required and unique opportunities to support the creation of unique evidence will be considered in subsequent steps of the project.

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