A Tool for Estimating the Health Benefits from Outdoor Recreation in Oregon

by
Tara Dunn

A THESIS

submitted to

Oregon State University

Honors College

in partial fulfillment of
the requirements for the
degree of

Honors Baccalaureate of Science in Natural Resources
(Honors Associate)

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AN ABSTRACT OF THE THESIS OF

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Abstract approved:____

Randall Rosenberger

The purpose of this project is to modify the Transportation Options Health Impact Estimator (TO Estimator) tool to quantify the health impacts of outdoor recreation in Oregon. The TO Estimator tool uses the Integrated Transportation and Health Impact Model (ITHIM) to quantitatively estimate the hypothetical health impacts of transportation mode shifts through changes to physical activity, air pollution, and injuries. The changes in physical activity are measured by shifts in active transportation like walking and cycling. The recreation modified version of the tool, Outdoor Recreation Health Impact Estimator (OR Estimator), increases the number of activities that can be measured to include 31 different outdoor recreation activities. Participation data from Oregon's Statewide Comprehensive Outdoor Recreation Plan (SCORP) survey is also incorporated in the tool to create a baseline for comparison. This report demonstrates how the tool might be used in Coos County, Oregon looking at changes in trail walking participation. An increase in trail walking from an average of 34.5 minutes/week to 150 minutes/week was estimated to reduce illness related costs by up to $5.3 million annually. The OR Estimator will enhance discussions about outdoor recreation management in Oregon. In addition, it will provide a tool that can be used by outdoor recreation managers and planners to articulate the impact recreation has on their communities, and use this information in recreation and community plans, grant applications, and project prioritization.

Key Words: Outdoor Recreation, Integrated Transportation and Health Impact Model, Health Benefits, Physical Activity, Cost of Illness

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I understand that my project will become part of the permanent collection of Oregon State University, Honors College. My signature below authorizes release of my project to any reader upon request.

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Tara Dunn, Author

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CHAPTER I. INTRODUCTION

To many people physical activity is synonymous with exercising at a gym: lifting weights or using the elliptical or treadmill, but physical activity encompasses much more than just that. People can be physically active at work, at home, while commuting, and while recreating outdoors. Regardless of when or how people are physically active it is an important part of leading a healthy life. This project uses quantitative modelling to illustrate how physical activity from outdoor recreation can impact people's health. The connection between physical activity and health, and therefore outdoor recreation and health, has been extensively studied in the literature, but using a model to quantify the relationship between outdoor recreation and health will provide new and useful information. Quantitative estimates of the health impacts from outdoor recreation may be important to parks and recreation managers, planners and policy makers as they make and justify decisions, allocate resources, and create healthier communities. This project provides a tool that can be used by outdoor recreation managers and planners to articulate the impact outdoor recreation has on the overall health of their communities, and use this information in recreation and community plans, grant applications, and project prioritization.

This thesis is comprised of four chapters. Chapter I discusses how physical activity impacts health and how the lack of physical activity are correlated with chronic illnesses. Chapter I also identifies the role the environment plays in influencing physical activity participation within a community. Chapter I concludes with an introduction to the modelling tool that was used in this project. Chapter II describes how the modelling tool operates and what adjustments were made to the original model that allowed it to be used for outdoor recreation applications in Oregon. Chapter III demonstrates how the modelling tool could be used to predict how changes in outdoor recreation participation could impact health outcomes. Chapter IV discusses how this modelling tool can be used in outdoor recreation management.

I.A. Physical Inactivity and Chronic Illness

Physical inactivity and sedentary lifestyles have increased with modern life because people are spending more time sitting in their cars, behind their desks, and on their couch; and it is killing people. In 2010, physical inactivity and poor diet were the two most influential risk factors for mortality in the U.S., surpassing tobacco, motor vehicles, and firearms (Maizlish, 2016). Daily physical activity provides a litany of benefits for people like increased memory function and improved quality of sleep. Physical activity can also decrease the risk of many chronic illnesses like heart disease, stroke, depression, dementia, diabetes and several cancers (e.g., breast, colon, endometrial, esophageal, kidney, stomach, lung) (2018 Physical Activity Guidelines Advisory Committee, 2018). In 2014, these chronic conditions made up five of the top ten leading causes of death (Maizlish, 2016).

The state of physical activity and associated chronic illnesses has become a growing public health concern, as well as a growing economic burden on the U.S. public. In the United States 11.1% of aggregate health care expenditures can be attributed to insufficient physical activity and sedentarism (Carlson, Fulton, Pratt, Yang, & Adams, 2015). In response to this crisis, the U.S. Department of Health and

Human Services published the first-ever Physical Activity Guidelines for Americans in 2008. The guidelines were based on a comprehensive report from the Physical Activity Guidelines Advisory Committee, made up of exercise science and public health experts. The guidelines included recommendations for aerobic and muscle strengthening activities. The Physical Activity Guidelines Advisory Committee found that 500 to 1,000 MET-minutes per week were required to receive substantial health benefits (2018 Physical Activity Guidelines Advisory Committee, 2018).

MET stands for metabolic equivalent task, where one MET is the typical energy expenditure of an individual at rest (1 kcal/kg/h). Activities are assigned MET values based upon how much energy they require to perform. METs are constants for activities and therefore are usually expressed as either MET-minutes or MET-hours. A MET-minute is a unit that describes the energy expenditure of a specific activity per minute. For example, walking at 3.0 mph requires 3.3 METs of energy expenditure and running at 6.0 mph is a 10 MET activity. Walking at 3.0 mph for 10 minutes would be expressed as 33 MET-minutes, whereas running at 6.0 mph for 10 minutes is 100 MET-minutes.

Despite the scientific evidence that physical activity plays a critical role for a healthy lifestyle, 80% of adult U.S. citizens are not meeting the minimum physical activity guidelines of 500 MET-minutes per week (Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Division of Population Health, 2015). There are a variety of ways someone could meet the minimum guideline of 500 MET-minutes. For example, if someone walked their dog (MET value of 3) every day for 25 minutes they would accumulate 525

MET-minutes every week (Ainsworth, et al., 2011). It is important to note that while the 500 MET-minutes per week result in “substantial” health benefits, any amount of physical activity is beneficial and the largest health improvements are received by those who are moving away from being sedentary to any physical activity (2018 Physical Activity Guidelines Advisory Committee, 2018).

I.A.1. Physical Activity in Oregon

Oregonians are above average in their non-work physical activity among all states in the U.S. According to the 2015 Behavioral Risk Factor Surveillance System (BRFSS) data, about 60% of adults met the aerobic activity recommendation, 30% met the muscle strengthening recommendation, with 23% meeting both the aerobic and muscle strengthening recommendation (Oregon Public Health Division, 2015). It was also reported that nearly 19% of adult Oregonians are sedentary in their non-work time. There is room for improvement in Oregonians’ physical activity rates, especially for the at risk sedentary population.

Substantial cost of illness savings (or conversely, health benefits) could be realized through increased physical activity in Oregon. Each year Oregonians spend $1.9 billion on cancer, $892 million on depression, $1.7 billion on diabetes, and $3.6 billion on cardiovascular disease (Haggerty & Hamberg, 2015). For comparison the annual K-12 education budget for Oregon is $8.2 billion, and the total cost for all those chronic diseases that could be reduced through increased physical activity is $8.1 billion annually (Pate, 2017).

Within Oregon there is a great deal of variation in physical activity participation rates across the 36 counties. According to BRFSS data from 2010-2013 the three counties with the highest percentage of people meeting the CDC guidelines for physical activity were Hood River (46.7%), Jefferson (36.2%^), and Lake (33.1%^) counties. The three counties with the lowest percentage of people meeting the CDC guidelines for physical activity were Coos (13%), Columbia (13.1%), and Umatilla (13.4%) counties. Figure 1.1 shows the participation rates for all Oregon counties.

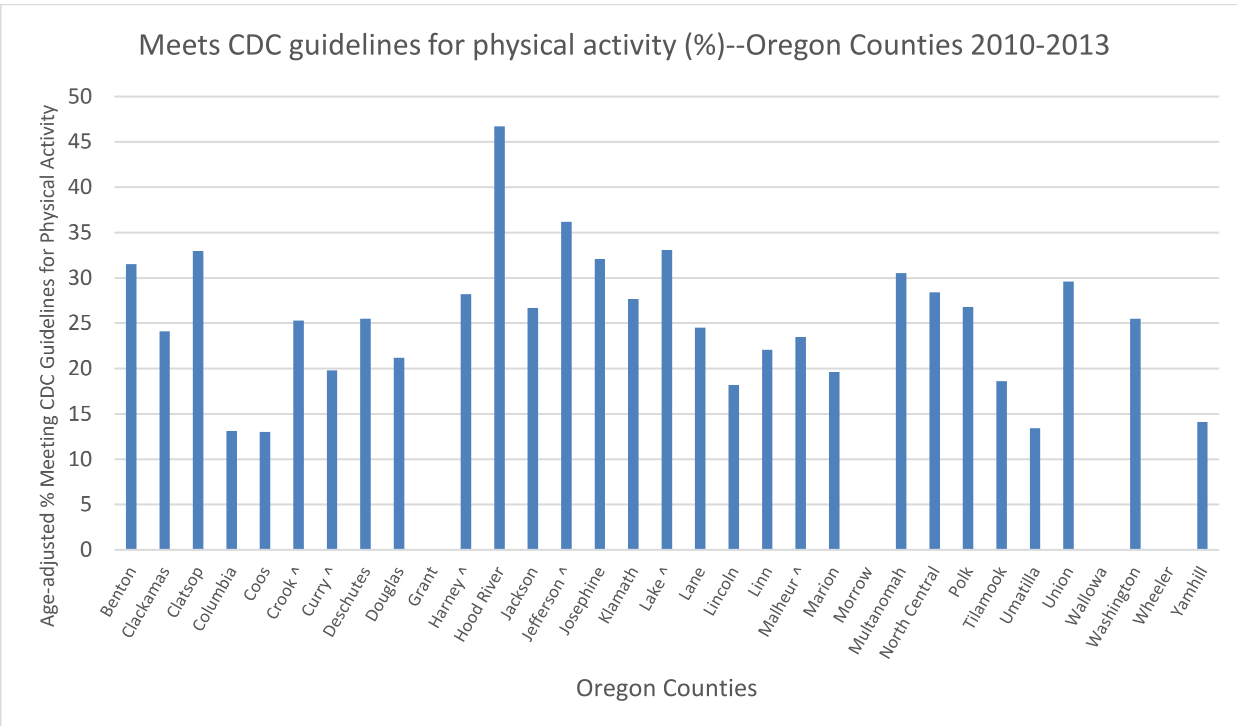


Figure 1.1 Percentage of Oregon counties that met CDC guidelines for physical activity, 2010-2013. Source: Oregon Behavioral Risk Factors Surveillance System 2010-2013 county combined; age-adjusted to the 2000 standard Population.

^ This number may be statistically unreliable and should be interpreted with caution.

The numbers for Baker, Grant, Morrow, Wallowa, and Wheeler counties are suppressed because they are statistically unreliable

North Central Public Health District includes Gilliam, Sherman, and Wasco counties.

I.B. Environmental Supports for Physical Activity

The largest predictor of a community's health is not the accessibility or quality of clinical care, but rather the social, economic, and physical conditions in which people live. These are considered "upstream" factors and they shape our environments (White & Blakesley, 2016). The environment that people live in can shape their physical activity participation. The 2018 Advisory Committee reviewed various interventions for promoting physical activity to determine what approaches were effective at increasing rates of physical activity. The 2018 Advisory Committee categorized the interventions into four different levels: individual, community-based, environmental and policy, and information and communications technologies. The evidence supporting the efficacy of environmental and policy interventions were found to be strong to moderate. Specifically, there was strong evidence suggesting point-of-decision prompts, like signs encouraging people to take the stairs instead of the elevator, to be effective and moderate evidence suggesting that built environments and infrastructure promoting active transportation, community design supporting physical activity (including active transportation), and access to indoor and outdoor facilities were effective interventions (2018 Physical Activity Guidelines Advisory Committee, 2018).

It is important to note that most epidemiological studies that link environmental factors with participation in physical activities have been conducted in urban environments. Generally, these studies look at land use mix, road design/street connectivity, urban planning policies (provision of parks, trails, or open spaces), neighborhood characteristics, and transportation infrastructure (sidewalks, bike lanes, trails). Environments that were more supportive of physical activity were generally found to have a positive influence on recreational physical activity participation. A review of 11 cross-sectional studies found that adults in neighborhoods that were more activity-supportive reported a median of 50.4 more minutes per week of moderate-to-vigorous physical activity and averaged about 13.7 minutes more of recreational walking compared with less supportive neighborhoods (2018 Physical Activity Guidelines Advisory Committee, 2018). The characteristics that were found in activity-supportive environments, as compared to less supportive environments were:

- Greater perceptions of safety
- Greater proximity of destinations (i.e. parks, stores, places of employment)
- Street connectivity
- Higher walkability indices (summary scores reflecting a combination of built environment characteristics, such as street connectivity, residential density, and land-use mix)
- Neighborhood aesthetics
- Absence of heavy traffic
- Greater access to indoor and outdoor recreation facilities or outlets, including parks, trails, and natural or green spaces

The environment can significantly influence the health of a community, but the decisions that shape these environments are mostly based on community development and transportation planning. Often, the health impacts are not always considered in parks and recreation development and planning. More and more often health is being talked about in these non-traditional spaces. In many communities the health and non-health sectors are working in closer collaboration to understand the influence environmental designs and decisions can have on community health.

I.B.1. The Role of Non-Health Sectors

The Oregon Department of Parks and Recreation (OPRD) plays an important role in providing spaces and opportunities for recreational physical activity that directly contributes to the public health of Oregon. A recent project of OPRD's is to quantify the health benefits of outdoor recreation on Oregon's public lands. The desire to quantify the health benefits of physical activity is not limited to only recreation providers. Transportation providers have also been increasingly interested in understanding the health impacts of active transportation options, like cycling and walking. These active transportation modes are viewed as potential solutions for multiple problems facing U.S. and international communities, including physical inactivity, air pollution in urban areas, and climate change from greenhouse gas emissions.

I.C. Integrated Transportation and Health Impact Modelling Tool

To better understand the health impacts of active transportation a tool called the Integrated Transport and Health Impact Model (ITHIM) was developed by Dr. James Woodcock and a team of leading researchers on transportation and health modeling (Maizlish & Linesch, 2016). The tool was first applied to scenarios in London, UK and Delhi, India, but since then the tool has become one of the leading approaches to quantify health impacts from transportation and has been widely used internationally. In the U.S. the tool has also been used in multiple applications in Tennessee, California, and Oregon (Haggerty & Hamberg, 2015).

ITHIM is a comprehensive health impact assessment model that uses comparative risk assessment to quantify the estimated change in life expectancy and quality of life for a population due to changes in active transportation participation. ITHIM predicts how changes in active transportation might impact a population's health by looking at three pathways: physical activity, injury, and air pollution (Centre for Diet and Activity Research, 2018). Although using all three pathways when analyzing the impact of proposed transportation change can provide a comprehensive picture of the potential effects on population health, it is also appropriate to use the model to analyze each pathway individually. The physical activity pathway, which focuses on changes in transportation related walking and cycling, has been found to have the largest impact on health outcomes. In some applications of ITHIM it has been recommended that only the physical activity pathway be used rather than all three pathways (Haggerty & Hamberg, 2015). The physical activity pathway estimates the health effects for active transportation scenarios based on quantified relationships between physical activity and chronic illnesses, like cardiovascular disease, diabetes, and some cancers (Green, et al., 2013).

ITHIM is a unique tool because it provides quantifiable estimates of health outcomes for population changes in physical activity level and is more customizable than other tools like the World Health Organizations Health Economic Assessment Tool (HEAT). For example, although ITHIM was developed for analyzing changes in cycling and walking, it has been modified to include other types of physical activities, such as jogging (White & Blakesley, 2016). For these reasons, ITHIM's applicability goes beyond the transportation sector. Results from the physical activity pathway of the model could provide similarly beneficial quantified health estimates to the outdoor recreation sector. This thesis describes how an Oregon specific version of ITHIM, called the Transportation Options Health Impact Estimator (TO Estimator) has been modified for use in the outdoor recreation sector in Oregon.

I.D. The Outdoor Recreation Health Impacts Estimator

This thesis develops and applies a tool that can be used to estimate the health impacts that could result from environmental interventions in communities, such as the construction of a new trail. The Outdoor Recreation Health Impacts Estimator (OR Estimator) tool is developed by modifying the TO Estimator to include a suite of outdoor recreation activities in Oregon. Just as the TO Estimator is a modification of the underlying ITHIM, including input and output user pages and prompts that increase accessibility of ITHIM to practitioners, the OR Estimator provides guided and simple input needs to increase accessibility for recreation and community planners.

A conceptual model of the tool links an environmental intervention to behavioral changes that result in changes in physical activity exposures, which in turn lead to improved health outcomes (figure 1.1). In other words, the new trail (environment) leads to increased walking (behavior) thus increasing physical activity (exposure), which results in a decrease in chronic diseases (health outcome). When the decrease in chronic diseases is monetized as a cost of illness savings, then the health outcome of the intervention may be quantified as an economic measure of health benefits due to the intervention. Although this is the conceptual flow of the tool's application, the tool itself only models the relationship between behavior change, exposure level, and health outcomes.

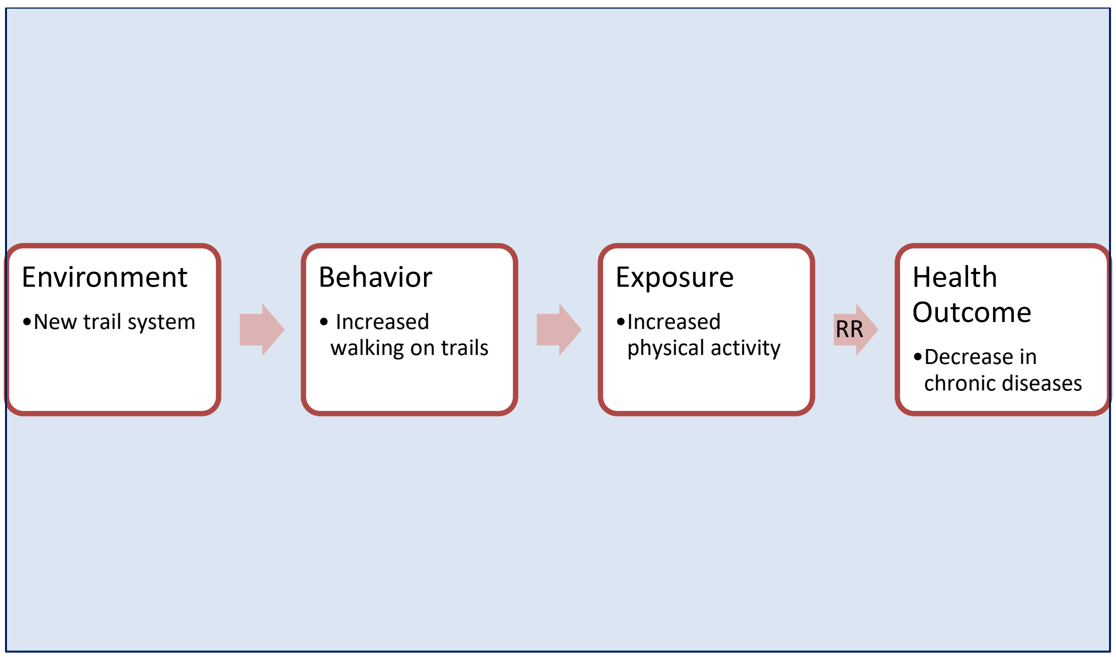


Figure 1.2 Outdoor Recreation Health Impact Estimator Conceptual Model.

Adapted from (Whitfield, 2015)

As previously discussed there is strong to moderate evidence in the literature that demonstrates the relationship between environmental changes and behavior changes related to physical activity, but this relationship is not quantified in a way that can be directly integrated into ITHIM. For example, the specific relationship between a new trail system and increased walking on trails is not quantified in a way that can be broadly applied to various communities. Therefore the relationship between environmental intervention and behavior change should be estimated for each application of the OR Estimator.

Prior to the development of the OR Estimator, the TO Estimator was applied to a new trail section proposal in Clatsop County to estimate potential health benefits from the project. In fact, it was this Clatsop County application that provided the idea to expand the TO Estimator for outdoor recreation use. Given the actual use of the new trail was no known, expected levels of use were defined based on the use and behavior for a similar and existing trail in the local area (White & Blakesley, 2016). In many cases use levels for new or change in existing facilities and parks may not be available. Therefore, it is recommended that similar methods (i.e., deriving needed information from locations and resources similar to the location and resource being evaluated and which have the needed information available) be used to localize the results as much as possible when using the OR Estimator. For more information on the suite of methods available to derive information from existing resources, see Johnston & Rosenberger (2010) and Rosenberger et al. (2017) on benefit transfer methods.

CHAPTER II. METHODS

II.A. ITHIM

II.A.1. Conceptual Basis

The conceptual basis of ITHIM uses a methodology known as comparative risk assessment (CRA). The CRA framework was first applied in 2000 as part of the World Health Organization's Global Burden of Disease Project (Haggerty & Hamberg, 2015). CRA compares scenarios to determine how a change in a risk factor will impact health outcomes. The comparison is between a baseline or 'business as usual' scenario and an alternative or counterfactual scenario. Changes in health outcomes are quantified by finding the proportional reduction in population disease or mortality that would occur if exposure to a risk factor were reduced to an alternative ideal exposure scenario (e.g., recommended levels of physical activity). The proportional reduction is called the Population Attributable Fraction (PAF) and is calculated using the following formula (see Figure 2.1) (Woodcock, et al., 2009).

$$PAF = \frac{\int_{\mathrm{Xmin}}^{\mathrm{Xmax}} RR(x)P(x)dx - \int_{\mathrm{Xmin}}^{\mathrm{Xmax}} RR(x)Q(x)dx}{\int_{\mathrm{Xmin}}^{\mathrm{Xmax}} RR(x)P(x)dx}$$

Figure 2.1 Formula for Population Attributable Fraction. Source: (Woodcock, et al., 2009)

CRA determines the health effect of a change in physical activity participation for a population by comparing population distributions of physical activity in a baseline scenario [P(x)] and an alternative scenario [Q(x)], conditional on the relative risk [RR(x)] for a disease. For example, CRA is used to determine how the PAF for stroke in a community would be affected by a change in cycling for transport from an average of 30 minutes/week to 60 minutes/week. The change in physical activity level represents a change in exposure level (x). For physical activity the exposure level is represented with MET-hours/week.

To calculate the PAF for a disease, the relative risk [RR(x)] of a disease for each exposure level is needed. Relative risk is the probability that a person develops a chronic condition or disease. Certain factors can influence relative risk, for example physical activity level can influence the relative risk of developing type II diabetes. As a person's level of physical activity increases the relative risk of that person developing diabetes decreases. This relationship between risk and exposure is represented mathematically with dose-response functions.

During the development of ITHIM the research team conducted systematic reviews of research for 8 conditions to determine their relationship to physical activity. These diseases were ischemic heart disease, hypertensive heart disease, stroke, diabetes, dementia (Alzheimer's disease), depression, and colon and breast cancer (Woodcock, et al., 2009). Evidence from this systematic review was used to create dose-response functions used to model the association between physical activity and disease outcome. There was some uncertainty about the shape of the relationship between exposure and risk so three alternatives were considered: a curvilinear relationship (regressing the square root of the exposure against the log RR), a linear relationship against the log RR, and a linear relationship with a threshold value (see Figure 2.2 below) (Woodcock, et al., 2009). The curvilinear relationship was used in the modelling because it is the most conservative.

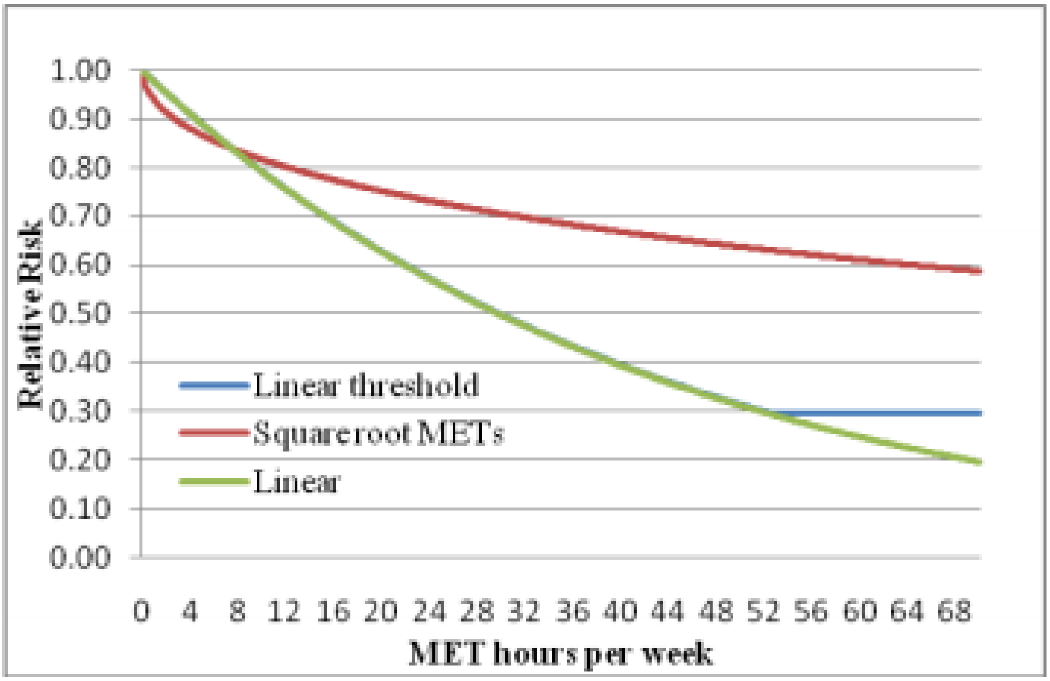


Figure 2.2 Alternative risk functions for physical activity and cardiovascular disease Source (Woodcock, et al., 2009).

II.A.2. Measurement of Health Outcomes

Population Attributable Fraction is not the final output for ITHIM. Baseline Global Burden of Disease data from the World Health Organization is combined with PAF to determine the change in disease burden (see Figure 2.3 below).

$$\Delta DB = \frac{\int_{\mathrm{Xmin}}^{\mathrm{Xmax}} RR(x)P(x)dx - \int_{\mathrm{Xmin}}^{\mathrm{Xmax}} RR(x)Q(x)dx}{\int_{\mathrm{Xmin}}^{\mathrm{Xmax}} RR(x)P(x)dx} \times DB_{Baseline}$$

where,

$$PAF = \frac{\int_{\mathrm{Xmin}}^{\mathrm{Xmax}} RR(x)P(x)dx - \int_{\mathrm{Xmin}}^{\mathrm{Xmax}} RR(x)Q(x)dx}{\int_{\mathrm{Xmin}}^{\mathrm{Xmax}} RR(x)P(x)dx}$$

Figure 2.3 Calculations required for measuring health outcomes with ITHIM.

The global burden of disease can be measured two different ways, with deaths or with disability adjusted life years (DALYs). These two measures have been used by the WHO to record the disease burden for countries all over the world (including the U.S.) since 1996. They are publicly available from the Global Burden of Disease Database in age-sex-and cause-groups (Maizlish & Linesch, 2016). The number of deaths from each disease is a simple measure of that disease's impact on a population, but it is not a comprehensive measure of the total impact of a disease because it does not account for the impact of disability. DALYs can be a more informative measure because it is a standardized unit of morbidity (Haggerty & Hamberg, 2015). DALYs is developed by the WHO and is the sum of years of life lost (YLL) and Years of Living with Disability (YLD). The following figure borrowed from Maizlish (2016) illustrates the concept of DALYs (see Figure 2.4).

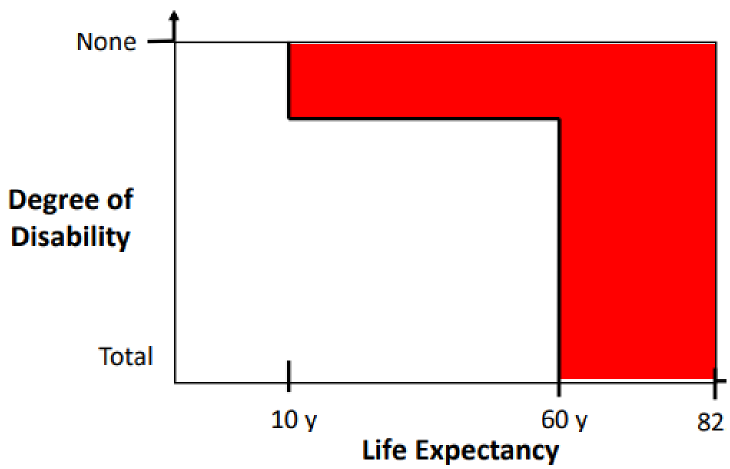


Figure 1.2 A woman who has a brain injury from a traffic collision at age 10 dies prematurely at age 60. Assuming a disability weight for injury at 0.63, her loss in DALYs is:

Years living with disability + years of life lost

(60y-10y) × 0.63 + (82.5y – 60y) × 1.0 = 15 + 31.5 = 46.5 y

Figure 2.4 Example illustrating DALYs. Source (Maizlish, 2016).

ITHIM did not originally have an economic measure of the health outcomes, but a monetized metric was found to be beneficial in communicating the results in an application in the U.S. Two different monetization strategies were used in the Tennessee application, cost of illness (COI) and value of a statistical life (VSL), but now only COI is used because it was found to be a more conservative and useful measurement (Whitfield, Meehan, Maizlish, & Wendel, 2016). There are national-level disease-specific direct treatment costs and lost productivity costs that make up COI estimates. The ITHIM-estimated change in disease burden is applied to COI estimates to determine the COI savings that would be associated with a change in physical activity behavior.

II.A.3. Calibration Data

If all three pathways of ITHIM (physical activity, air pollution, and injury) are being utilized there are 14 key parameters for the baseline calibration data that are needed. However, if only the physical activity pathway is being used, then fewer calibration data are needed. The data that are needed for the physical activity pathway are described in table 2.1 (see below). The data needed for ITHIM are available from international, national, and state level travel and health surveys and databases (Maizlish, et al., 2012).

Table 2.1 Key Parameters and Their Definitions, Units, and Strata for Baseline Calibration

No.	Item Definition	Units	Strata
1	Per capita mean daily travel distance	Miles/person/ day	Age and sex by mode
2	Ratio of per capita mean daily active travel time (relative to females aged 15-29 years old)	Dimensionless	Walk, bicycle
3	Per capita mean daily travel time	Min/person/ day	Travel mode
4	Standard deviation of mean daily active travel time	Min/person/ day	Walk+bicycle
5	Distribution of population by age and gender	Percent	None
6	Age-sex specific ratio of disease-specific mortality rate between geographic area and United States	Dimensionless	Global burden of disease group
7	Proportion of colon cancers from all colo-rectal cancers	Dimensionless	NA
8	Average walk speed (informational only)	Miles / hour	Walk
9	Per capita weekly non-travel related physical activity expressed as metabolic equivalent tasks (kcal/kg body weight/hr of activity)	MET-hours/week	Median of quintile of walk+bicycle METs

II.A.4. Assumptions of ITHIM

One of the most significant assumptions of the model is that all the health benefits attributed to the change in physical activity occur in a single "accounting year". This is an oversimplification because the benefits would be realized gradually over a much longer period (Woodcock, et al., 2009). The model also assumes that there are no exterior changes to the health of a community, outside of changes to physical activity from transportation (i.e. non-travel physical activity and disease prevalence are constant) (Woodcock, et al., 2009). Another assumption of the ITHIM model is that as physical activity increases for a population the log normal distribution of travel-related physical activity becomes less skewed (Maizlish & Linesch, 2016). Due to the availability of health data the model also assumes that disease rates are the same throughout the geographic area in question.

II.B. Transportations Options Health Impact Estimator

Although the inputs are relatively simple the calibration of the tool can be an arduous task because acquiring, cleaning, formatting, and entering the data requires “considerable statistical analyses and data management skills” (Whitfield, Meehan, Maizlish, & Wendel, 2016). The Oregon Health Impact Assessment Program adapted the ITHIM model for application in Oregon—the Transportation Options Estimator (TO Estimator). The TO Estimator reduces the overall data needs of ITHIM, thus lowering barriers of access for some communities. The TO Estimator has most of the calibration data needed for ITHIM built into the tool. The distribution of population by age and gender and per capita weekly non-travel related physical activity is localized to Oregon counties. Similarly the burden of disease data is built into the tool, but only has urban/rural resolution, rather than county resolution. The TO Estimator also includes county baseline data about the per capita mean travel behaviors based on estimates from the Oregon Household Activity Survey.

In addition, the TO Estimator added “user pages” for inputs and outputs. The input user page provides an easy to read, simplified “worksheet” with prompts and instructions for users to fill in the necessary calibration data (see Figure 2.5). The outputs user page displays the summarized health estimates produced by the model in easy to read graphs and tables (see Figure 2.6). The basic inputs that are required by users of the TO Estimator are 1) additional miles traveled by mode as a result of an intervention or infrastructure change 2) the duration of the intervention (if applicable, the default is to estimate over one year), and 3) the number of people affected or influenced by the change (Haggerty & Hamberg, 2015).

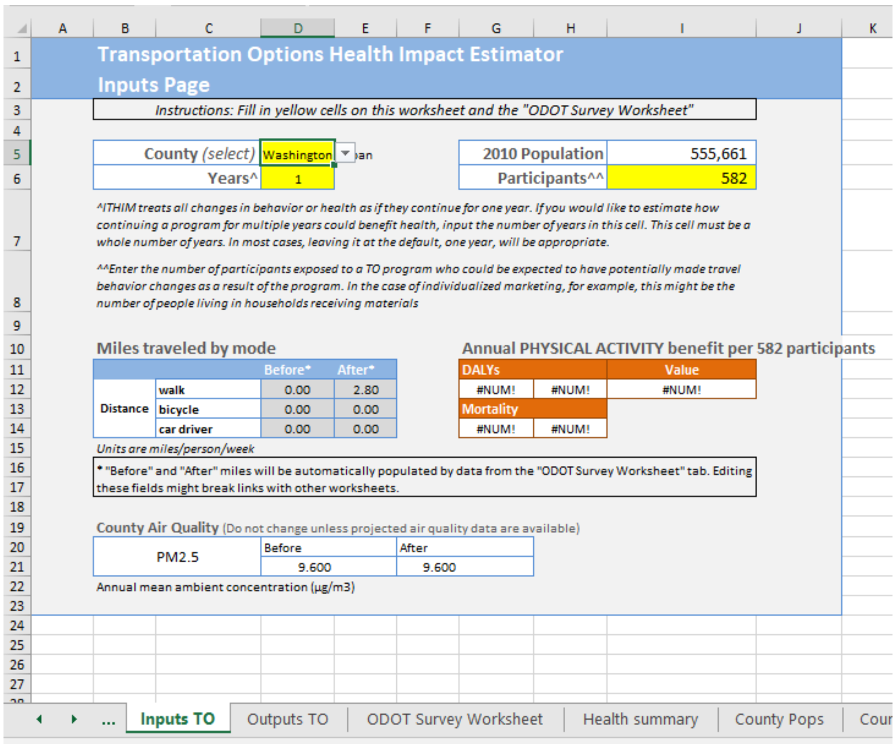


Figure 2.5 TO Estimator Inputs User Page.

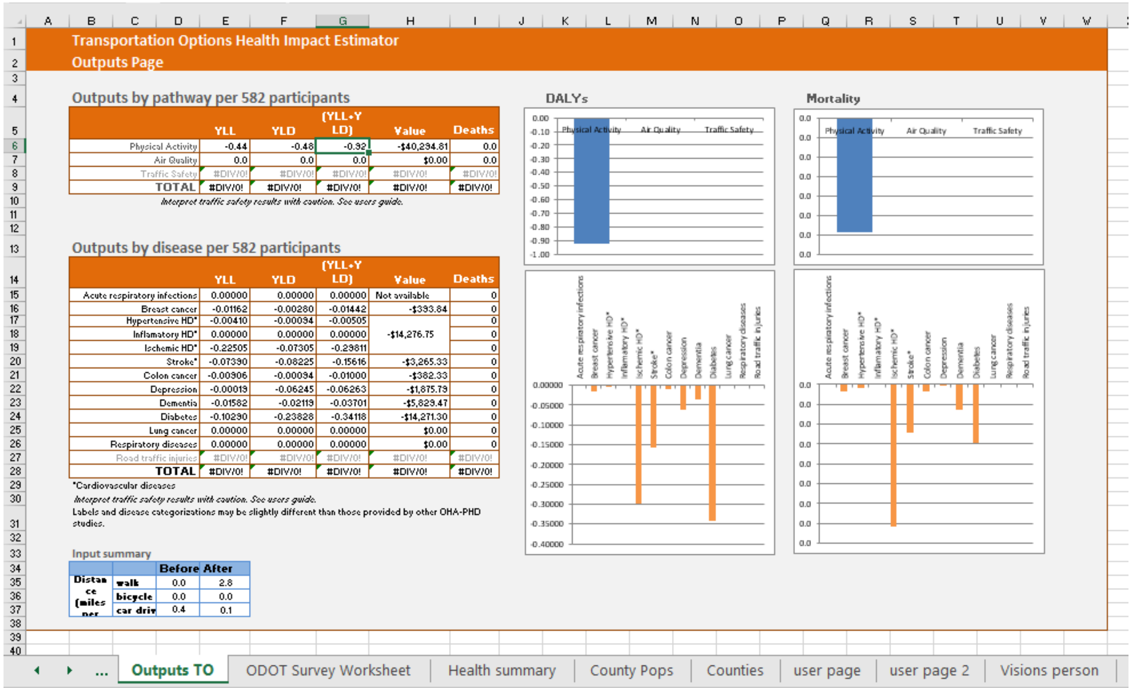


Figure 2.6 TO Estimator Outputs User Page.

II.C. Outdoor Recreation Health Impact Estimator

II.C.1. MET Adjustments

The TO Estimator was designed to assess the health impacts related to changes in cycling and walking behavior, which are the two main types of active transportation. If the TO Estimator is to account for outdoor recreation in general, then more types of activities need to be accommodated beyond cycling and walking. The TO Estimator was modified to work for 31 different outdoor recreation activities by adjusting the MET values in the model. For all 31 activities the MET values were based on MET values for activities listed in the 2011 Ainsworth Compendium of Physical Activities (see Appendix A) (Ainsworth, et al., 2011). The original MET values in the TO Estimator were 3 and 6 for walking and cycling, respectively. For the modified recreation version, if an activity was determined to be moderatelyintense (MET>=3 and <6), then the MET value for walking in the TO Estimator was adjusted to the MET value for that activity. If an activity was determined to be vigorously-intense (MET>6), then the MET value for cycling was adjusted to the MET value for that activity. For example, for horseback riding the MET value is 3.8 so the MET value for walking was adjusted from 3 to 3.8 in the tools baseline and scenario calibration pages (see Figure 2.7 below). Alternatively, if the model is estimating the impact of a vigorous activity like backpacking (MET=7) then the MET value for cycling is adjusted from 6 to 7 (see Figure 2.7 below). Activities with MET values less than 3 are not considered to be aerobic, do not produce the same level of health outcomes, and therefore are not modelled by ITHIM.

METs			
min	3.8	min	0.0
Horseback riding		Vigorous Activities	
m	f	m	f
3.8	3.8	0	0
3.8	3.8	0	0
3.8	3.8	0	0
3.8	3.8	0	0
3.8	3.8	0	0
3.8	3.8	0	0
3.8	3.8	0	0
3.8	3.8	0	0

METs			
min	0.0	min	7.0
Moderate Activities		Long-distance hiking (back packing)	
m	f	m	f
0.0	0.0	7	7
0.0	0.0	7	7
0.0	0.0	7	7
0.0	0.0	7	7
0.0	0.0	7	7
0.0	0.0	7	7
0.0	0.0	7	7
0.0	0.0	7	7

Figure 2.7 MET Adjustment Examples

II.C.2. Recreation Baseline Data

The TO Estimator simplified the use of ITHIM for users by building in baseline and calibration data into the tool. Most of this calibration information is appropriate for recreation applications, but some information needed to be modified for the Outdoor Recreation Health Impact Estimator (OR Estimator). The current rates of participation in cycling and walking were replaced with the current rates of participation for all of the outdoor recreation activities. The participation rates were calculated from the 2017 Statewide Comprehensive Outdoor Recreation Plan (SCORP) participation survey for Oregon (Bergerson, 2018). SCORP must be completed every five years by the state in order to remain qualified for statewide Land and Water Conservation Fund. SCORP includes a statewide survey about outdoor recreation participation. The information needed from the SCORP survey came from questions in the activity participation tables (see Appendix B for example participation table). Respondents were asked to recall how many times they participated in an activity during the past year. Additionally, respondents were asked to report the average number of hours they participated in a typical occasion for each activity. From these data the median weekly hours of participation in each activity for the population-adjusted sample was calculated. The median participation value was used rather than the average value because of concerns of over reporting due to recall and avidity bias.

Another modification of SCORP participation data to fit the TO Estimator was by county characteristics. The TO Estimator categorizes counties as urban or rural for modelling purposes. Respondents of the SCORP survey were asked about how they would describe their community (rural, urban, or suburban). The urban and suburban subsamples' participation rates were combined, resulting in two different median minutes/week being calculated from the SCORP data—rural participation and urban participation. The median minutes/week for each activity can be found in Appendix C.

The number of participants in each activity for each county was determined from the participant rates for urban, suburban, and rural Oregonians from the SCORP survey data. Urban and suburban rates were averaged to determine the "urban" participation rate. The participation rates for all the activities can be found in Appendix D. The number of participants for each county was estimated by multiplying the 2010 county population by its corresponding participation rate.

II.C.3. Required User Inputs

Given the extensive baseline and calibration data that has been built into the OR Estimator there are only three inputs required for users: 1) select the county of interest, 2) select the activity of interest, and 3) enter the alternative scenario minutes of weekly participation. An example of a user application is outlined in Chapter III.

II.C.4 Assumptions

The ITHIM and TO Estimator were both designed to model the health impact of shifts in transportation related walking and cycling, modifying the model for outdoor recreation activities is dependent on several assumptions.

- A core assumption of this project is that the health impacts (and their distribution) from physical activity are only dependent on MET exposure and do not vary for different activities. This is because the physiological response to levels of aerobic intensity and duration is relatively independent of the activity type. The Physical Activity Recommendations are based on this assumption—it is the duration and intensity of the activity that matter.

- Another assumption inherent in the recreation model is that the health benefits from physical activity outweigh any risk of injury associated with participating in the activities. When the model was applied in transportation it was determined that the benefits outweighed the risks, but this assumption may not be accurate for all outdoor recreation activities (Haggerty & Hamberg, 2015). For this project, we also do not account for injury risk.
- Another assumption is that an increase in participation in one activity does not correspond to a decrease in participation in another activity (i.e., no activity substitution). Therefore, an intervention leads to a net behavioral change—i.e., positive if it increases physical activity (e.g., a new trail), or negative if it decreases physical activity (e.g., closure or restricted access to a trail).
- METs are held constant for men and women and across all age groups in the OR Estimator, which may not accurately reflect the level of METs for each of the activities.
- The OR Estimator also assumes that non-travel METs in the model are equivalent to "non-outdoor recreation" METs. More specifically that non-travel METs are equivalent to the METs that people obtain through other activities other than the activity that is being measured in the model (e.g., skiing or swimming). Non-travel METs represent the physical activity that the population participates in outside of active transportation, specifically

leisure time physical activity and occupation related physical activity. The estimates for leisure time and occupational related physical activity come from public health surveys.

- Estimates for different activities for a location or resource should not be added-up given this will compound the potential for exaggerated health benefits.

II.C.5. Data Limitations

Many of the recreation activity inputs are based on SCORP survey data, where all surveys include some level of error in respondent answers or missing information. The 2017 SCORP was a statewide participation survey without enough resolution to capture county-level participation rates. Therefore, counties are demarcated by urban and rural characteristics. The SCORP survey also asked respondents to recall their activity participation for the past year and may include some recall bias in the responses (Hassan, 2005). Another limitation of the data is in the format of the question about time spent participating during an average occasion. The format of this question asked respondents to indicate the average number of hours they participated in an activity on a typical occasion. The lowest duration reported was 1 hour, which either means the survey did not allow fractions, or people generally rounded to the nearest whole hour. It is also not clear if respondents included time not spent engaging in physical activity as part of their estimate (i.e., travel to and or from destinations, snack or meal breaks, etc.).

CHAPTER III. EXAMPLE APPLICATION

Walking on local trails or paths in Coos County will be used as an example application that helps illustrate the health benefits metrics modelled by the OR Estimator. Coos County was selected because it is rural and has the lowest reported percentage of its population meeting the minimum physical activity guidelines among all Oregon counties at 13% (Oregon Health Authority, Public Health Division, Health Promotion and Chronic Disease Prevention section, 2015). Walking on local trails and paths was selected as the example activity because this type of activity was identified as a high priority environmental intervention in the 2018-2022 SCORP report (Bergerson, 2018).

The scenario in this example application is a hypothetical intervention in Coos County that expands a walking trail network or system that increases the average trail users trail walking time from 35 minutes/week to 150 minutes/week, or the recommended minimum physical activity rate. Implementation of this scenario in the OR Estimator uses the following steps (see figure 3.1):

1. Go to the "Recreation Worksheet" of the OR Estimator
2. Use the drop down menu in cell B3 to select the county: "Coos"
3. Use the drop down menu in cell B8 to select the activity: "walking on local trails or paths"
4. Once the county and activity have been selected the information in the blue cells (B4:B7,B9 and B10) will be autopopulated from information from the "Recreation Calibration" and "County" pages.
    a. Since Coos County is rural the "county type" will be "rural"

b. The “current % of the total population participating” in “walking on local trails or paths” will be determined based on rural participation rates found on the “Recreation Calibration” page: 68%
c. The “county population” will be automatically populated based on 2013 county population estimates recorded on the “County” page: 62,557 adults
d. The “current # of users” will be calculated by multiplying “county population” by “current % of total population participating”: 42,538 adults
e. The “MET value for this activity” will be filled from information on the “Recreation Calibration” page: 3.5 METs
f. The “Minutes of Moderate Activity/Week” is automatically filled from rural participation information in the “Recreation Calibration” page that is specific to “walking on local trails or paths”: 35 minutes/week

5. The final step is entering a value for “Desired Weekly Participation” (B11). For this example the minutes/week will be set at 150 minutes/week to represent a scenario in which participants are meeting the minimum physical activity guidelines entirely by walking on local trails or paths.

Inputs	
Instructions: Fill in yellow cells on this worksheet (blue cells will be automatically filled)	
County *(select)*	Coos
County Type	Rural
Current % of Total Population Participating	68%
County Population	62,557.00
Current # Users	42,538.76
Activity *(select)*	Walking on local trails or paths
MET Values For Activity	3.5
Minutes of Moderate Activity/Week	34.52054795
Desired Weekly Participation (weekly minutes per participant)	150

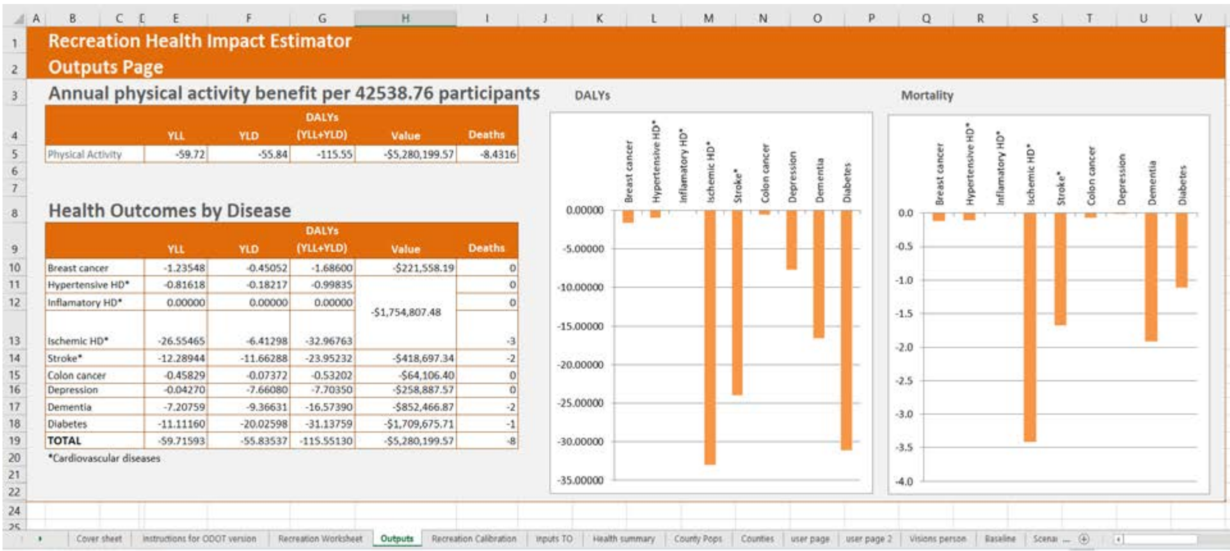
Annual physical activity benefit per 42538.76 participants	
More in depth outputs can be found on the Outputs page	
Deaths	-8.431584102
YLL	-59.72
YLD	-55.84
DALYs	-115.55
Value	**-$5,280,199.57**

Cover sheet | Instructions OR version | Recreation Worksheet | Outputs | Recreation Calibration | Inputs TO | Health summary | County Pops | Counties | user page | user page 2 | Visions person | Baseline | Scenario

Figure 3.1 Recreation user worksheet for example application.

The Recreation Worksheet page provides a brief synopsis of the health outcomes that have been modelled (see Figure 3.1). These results are cumulative for all participants and are not per capita. The outputs summarized on the "Recreation Worksheet" include: deaths, years of life lost (YLL), years lost due to disability (YLD), Disability Adjusted Life Years (DALY), and Cost of Illness (labeled as "value"). Negative outcomes (up to -8 deaths, -60 YLL, -56 YLD, -116 DALYs, -$5.3 million) represent avoided burden or cost. It is important to note that cost of illness comprises both direct (health care spending) and indirect (lost productivity due to absenteeism) costs and is an upward bound estimate. It is also important to note avoided costs are not equivalent to reduced costs or expenditures as the money that would have been spent related to these chronic diseases could be spent elsewhere in the health care sector (i.e., preventative care or unrelated illnesses).

The “outputs” page provides a more comprehensive summary of the estimated health outcomes broken down by disease (see Figure 3.2). In the Coos County example the diseases with the highest savings associated with this level of physical activity are cardiovascular diseases (up to $1.75 million), diabetes (up to $1.7 million), and dementia (up to $0.85 million).


Recreation Health Impact Estimator
Outputs Page
Annual physical activity benefit per 42538.76 participants

	YLL	YLD	DALYs (YLL+YLD)	Value	Deaths
Physical Activity	-59.72	-55.84	-115.55	-$5,280,199.57	-8.4316

Health Outcomes by Disease

	YLL	YLD	DALYs (YLL+YLD)	Value	Deaths
Breast cancer	-1.23548	-0.45052	-1.68600	-$221,558.19	0
Hypertensive HD*	-0.81618	-0.18217	-0.99835	-$1,754,807.48	0
Inflamatory HD*	0.00000	0.00000	0.00000		0
Ischemic HD*	-26.55465	-6.41298	-32.96763		-3
Stroke*	-12.28944	-11.66288	-23.95232	-$418,697.34	-2
Colon cancer	-0.45829	-0.07372	-0.53202	-$64,106.40	0
Depression	-0.04270	-7.66080	-7.70350	-$258,887.57	0
Dementia	-7.20759	-9.36631	-16.57390	-$852,466.87	-2
Diabetes	-11.11160	-20.02598	-31.13759	-$1,709,675.71	-1
TOTAL	-59.71593	-55.83537	-115.55130	-$5,280,199.57	-8

*Cardiovascular diseases

Figure 3.2 Health outcomes by disease for example application.

CHAPTER IV. DISCUSSION

ITHIM is an effective model that has been used to foster important discussions about the connection between transportation and health. Modifying the model to integrate outdoor recreation participation can foster similarly important conversations about the connection between health and outdoor recreation. Due to the assumptions of the model it is important to recognize that the purpose of ITHIM is "to estimate the magnitude and direction of potential net health impacts rather than to precisely forecast disease burdens" and should not be used to plan health services budgets or future disease burdens (Whitfield, Meehan, Maizlish, & Wendel, 2016). Although the model does not provide any information on what projects, policies, or infrastructure will result in changes in outdoor recreation participation, the results can be used to better understand how changes are expected to impact a community and thus motivate recreation design interventions for public health improvements.

The health of a community is not the sole responsibility of clinicians and health care providers, rather it is the responsibility of an entire community, including individuals, planners, and recreation providers, among others. Providers of outdoor recreation infrastructure and opportunities play an important role in providing a healthy place for people to live. Outdoor recreation providers can offer and improve infrastructure, increase access, remove barriers, and provide valuable information to communities to help enable people to become more physically active. If these interventions are successful at increasing physical activity participation, then they will improve the overall well-being of the community through improved health outcomes.

Quantifying the health outcomes impacted by outdoor recreation complements communications about the importance of both health and recreation for a community. The OR Estimator is especially useful because it provides an economic measure of the health impacts of a proposed change. The cost of illness savings could be compared to the cost of an intervention like trail expansion as a justification for public spending. This information could also provide justification for communities, like Coos County, if they were to apply for project funding from the Land and Water Conservation Fund or Recreational Trails Program to improve access to trail systems or other outdoor recreation opportunities. The estimates produced by the OR Estimator provide supporting documentation for investing in more trails, more diverse trail types, and trail accessibility or other outdoor recreation interventions as a public health strategy.

CHAPTER V. ACKNOWLEDGEMENTS

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APPENDIX A. Derived MET values from the Ainsworth Compendium (2011).

SCORP Category	Compendium Code	Compendium Category	MET Value	Intensity level
Walking on local streets or sidewalks	17160	walking for pleasure (Taylor Code 010)	3.5	moderate
Walking on local trails or paths	17160	walking for pleasure (Taylor Code 010)	3.5	moderate
Walking / day hiking on non-local trails or path	17080	walking for pleasure (Taylor Code 010)	3.5	moderate
Long-distance hiking (back packing)	17010	backpacking (Taylor Code 050)	7.0	vigorous
Jogging or running on streets or sidewalks	12020	jogging, general	7	vigorous
Jogging or running on trails or paths	12020	jogging, general	7	vigorous
Horseback riding	15400	horseback riding, walking	3.8	moderate
Bicycling on unpaved trails	1013	bicycling, on dirt or farm road, moderate pace	5.8	moderate
Bicycling on paved trails	1018	bicycling, leisure, 5.5 mph	3.5	moderate
Bicycling on roads, streets or sidewalks	1018	bicycling, leisure, 5.5 mph	3.5	moderate
Class I – All-terrain vehicle riding (3 & 4 wheel ATVs, straddle seat and handle bars)	15470	moto-cross, off-road motor sports, all-terrain vehicle, general	4.0	moderate
Class II – Off-road 4-wheel driving (jeeps,	NA	NA	NA	NA

pickups, dune buggies, SUVs)				
Class III – Off-road motorcycling	15470	moto-cross, off-road motor sports, all-terrain vehicle, general	4.0	moderate
Class IV – Riding UTVs or side-by-side ATVs (non-straddle seat, driver and passenger sit side by-side in the vehicle, steering wheel for steering control)	15470	moto-cross, off-road motor sports, all-terrain vehicle, general	4.0	moderate
Snowmobiling	19200	snowmobiling, driving, moderate	3.5	moderate
Using personal water craft, such as jet ski	18160	jet skiing, driving, in water	7	vigorous
Power boating (cruising or water skiing)	18010	boating, power, driving	2.5	
Downhill (alpine) skiing or snowboarding	19150	skiing, downhill, alpine or snowboarding, light effort, active time only	4.3	moderate
Cross-country / nordic skiing / skijoring on groomed trails	19080	skiing, cross country, 2.5 mph, slow or light effort, ski walking	6.8	vigorous
Cross-country / nordic skiing / skijoring on ungroomed trails or off designated trails	19080	skiing, cross country, 2.5 mph, slow or light effort, ski walking	6.8	vigorous
Snowshoeing	19190	snow shoeing, moderate effort	5.3	moderate
Sledding, tubing, or general snow play	19180	sledding, tobogganing, bobsledding, luge (Taylor Code 370)	7.0	vigorous
Sightseeing / driving or motorcycling for pleasure	NA	NA	NA	NA

Picnicking	9100	retreat/family reunion activities involving sitting, relaxing, talking, eating	1.8	
Taking your children or grandchildren to a playground	NA	NA	NA	NA
Dog walking or going to dog parks / off leash areas	17165	walking the dog	3	moderate
Relaxing, hanging out, escaping heat / noise, etc.	9100	retreat/family reunion activities involving sitting, relaxing, talking, eating	1.5	
Attending outdoor concerts, fairs, or festivals	9115	sitting at a sporting event, spectator	1.5	
Tennis (played outdoors)	15685	tennis, doubles	4.5	moderate
Pickleball (played outdoors)				
Outdoor court games other than tennis (basketball, beach volleyball, badminton, etc.)	15030	badminton, social singles and doubles, general	5.5	moderate
Soccer	15610	soccer, casual, general (Taylor Code 540)	7	vigorous
Futsal	15610	soccer, casual, general (Taylor Code 540)	7	vigorous
Golf	15290	golf, using power cart (Taylor Code 070)	3.5	moderate
Orienteering or geocaching	15480	orienteering	9.0	vigorous
Visiting historic sites or history-themed parks (history-oriented museums, outdoor displays, visitor centers, etc.)	NA	NA	NA	NA

Bird watching	17085	bird watching, slow walk	2.5	
Whale watching	NA	NA	NA	NA
Exploring tidepools	NA	NA	NA	NA
Other nature / wildlife / forest / wildflower observation	NA	NA	NA	NA
Taking your children or grandchildren to nature settings	NA	NA	NA	NA
Visiting nature centers	NA	NA	NA	NA
Outdoor photography, painting, or drawing	9020	drawing, writing, painting, standing	1.8	
Collecting (rocks, plants, mushrooms, or berries)	8250	implied walking/standing - picking up yard, light, picking flowers or vegetables	3.0	moderate
Hunting	4086	hunting large game from a car, plane, or boat	2.0	
Fishing	4061	fishing, jog or line, standing, general	1.8	
Crabbing	4005	fishing, crab fishing	4.5	moderate
Shellfishing / clamming	NA	NA	NA	NA
White-water canoeing, kayaking, or rafting	18370	whitewater rafting, kayaking, or canoeing	5.0	moderate
Flat-water canoeing, sea kayaking, rowing, stand-up paddling, tubing / floating	18352	tubing, floating on a river, general	2.3	
Beach activities – ocean	NA	NA	NA	NA
Beach activities – lakes, reservoirs, rivers, etc.	NA	NA	NA	NA
Swimming or playing in outdoor pools / spray parks	18310	swimming, leisurely, not lap swimming, general	6.0	vigorous

APPENDIX B. Example SCORP participation survey question.

Q2. Please look at the activities listed in the table below, and exclude snow-based ones that we will ask about later. Did you participate in any non-motorized trail or related activities in Oregon during the past 12 months?

- If NO, please move on to **question 3 (Q3).**
- If YES, please fill out the following table only for the activities that you participated in during **the 12 months (May 2016 – April 2017)**.

Non-motorized trail or related activities	**Column A** Number of times **YOU** participated	**Column B** Average number of hours **YOU** participated in a typical occasion	**Column C** Average number of **OTHER** household members that participated **with YOU** each time
Walking on local streets or sidewalks			
Walking on local trails or paths			
Walking / day hiking on non-local trails or paths			
Long-distance hiking (back packing)			
Jogging or running on streets or sidewalks			
Jogging or running on trails or paths			
Horseback riding			
Bicycling on unpaved trails			
Bicycling on paved trails			
Bicycling on roads, streets or sidewalks			

APPENDIX C. Minutes/week spent participating in each activity (median participant)

	Rural	Urban
Walking on local streets or sidewalks	100.68	161.67
Walking on local trails or paths	34.52	35.67
Walking / day hiking on non-local trails or path	27.62	24.16
Long-distance hiking (back packing)	27.62	24.16
Jogging or running on streets or sidewalks	46.03	57.53
Jogging or running on trails or paths	23.01	28.77
Bicycling on roads, streets or sidewalks	34.52	43.15
Class I – All-terrain vehicle riding (3 & 4 wheel ATVs, straddle seat and handle bars)	25.32	20.71
Class III – Off-road motorcycling	46.03	43.73
Class IV – Riding UTVs or side-by-side ATVs (non-straddle seat, driver and passenger sit side by-side in the vehicle, steering wheel for steering control)	48.33	16.11
Snowmobiling	42.00	28.77
Using personal water craft, such as jet ski	13.81	23.01
Downhill (alpine) skiing or snowboarding	25.32	23.01
Cross-country / nordic skiing / skijoring on groomed trails	11.51	9.205
Cross-country / nordic skiing / skijoring on ungroomed trails or off designated trails	11.51	11.51
Snowshoeing	6.90	7.48
Sledding, tubing, or general snow play	6.90	6.90
Dog walking or going to dog parks / off leash areas	34.52	57.53
Tennis (played outdoors)	5.75	10.93
Outdoor court games other than tennis (basketball, beach volleyball, badminton, etc.)	17.26	16.97
Soccer	23.01	34.52
Futsal	11.51	19.85
Golf	27.62	27.62
Orienteering or geocaching	17.26	7.48
Collecting (rocks, plants, mushrooms, or berries)	17.26	11.51
Crabbing	13.81	10.93
White-water canoeing, kayaking, or rafting	13.81	9.20
Swimming or playing in outdoor pools / spray parks	13.81	15.53

APPENDIX D. Percentage of Oregonians Participating in Outdoor Recreation Activity Types from SCORP Data.

	Rural	Urban
Walking on local streets or sidewalks	77%	85%
Walking on local trails or paths	68%	75%
Walking / day hiking on non-local trails or path	52%	56%
Long-distance hiking (back packing)	11%	14%
Jogging or running on streets or sidewalks	16%	30%
Jogging or running on trails or paths	12%	24%
Horseback riding	8%	3%
Bicycling on unpaved trails	13%	16%
Bicycling on paved trails	19%	34%
Bicycling on roads, streets or sidewalks	26%	42%
Class I – All-terrain vehicle riding (3 & 4 wheel ATVs, straddle seat and handle bars)	17%	6%
Class III – Off-road motorcycling	5%	3%
Class IV – Riding UTVs or side-by-side ATVs (non-straddle seat, driver and passenger sit side by-side in the vehicle, steering wheel for steering control)	9%	3%
Snowmobiling	3%	2%
Using personal water craft, such as jet ski	4%	4%
Downhill (alpine) skiing or snowboarding	9%	14%
Cross-country / nordic skiing / skijoring on groomed trails	3%	7%
Cross-country / nordic skiing / skijoring on ungroomed trails or off designated trails	3%	4%
Snowshoeing	8%	11%
Sledding, tubing, or general snow play	26%	27%
Dog walking or going to dog parks / off leash areas	35%	37%
Tennis (played outdoors)	5%	7%
Outdoor court games other than tennis (basketball, beach volleyball, badminton, etc.)	7%	11%
Soccer	5%	9%
Futsal	0%	1%
Golf	13%	14%
Orienteering or geocaching	6%	5%
Collecting (rocks, plants, mushrooms, or berries)	34%	25%
Crabbing	13%	9%
White-water canoeing, kayaking, or rafting	12%	11%
Swimming or playing in outdoor pools / spray parks	21%	27%