Walk.Bike.Ohio

Estimated Health Impacts

2020

Ohio Department of Transportation

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INTRODUCTION

How we travel within our communities can greatly affect our physical, mental, and social health and well-being. Second only to socioeconomic factors, developing the built environment, by creating opportunities for making healthy travel options the default choice, has the most potential to impact health outcomes in our community (Frieden, 2010). When residents have access to connected and safe places to walk and bicycle, it is easier to expand social connections, address mental health, and engage in more physical activity. In turn, increased physical activity – including even small shifts from sedentary behavior to lower levels of activity – can help reduce the risk of various diseases and health conditions (Kyu, 2016).

Purpose

This technical memorandum builds on robust evidence demonstrating the connection between active transportation- and land use-related interventions, physical activity, and disease prevention (US Preventive Services Task Force, 2016) to estimate how shifts in walking and bicycling activity can impact the health and lives of us and our neighbors.

ILLNESSES & DISEASES

Currently, several illnesses and diseases directly affect Ohio residents each year.

Table 1 shows mortality rates per 100,000 people for select illnesses among Ohio women in 2017. Heart disease had the highest mortality rate for females between the ages of 25-44, 45-54, 65-74, and 75+ (7.9 deaths, 28.3 deaths, 171.1 deaths, and 929.9 deaths per 100,000 women, respectively). Lung cancer had the highest mortality rate for females between the ages of 55-64 (79.1 deaths per 100,000 women).

Table 2 shows mortality rates per 100,000 people for select illnesses among Ohio men in 2017. Diabetes had the highest mortality rate for males between the ages of 15-24 (1.5 deaths per 100,000 men). Heart disease had the highest mortality rate for males between the ages of 25-44, 45-54, 55-64, 65-74, and 75+ (12.3 deaths, 77.6 deaths, 206.7 deaths, 377.7 deaths, and 1,382.9 deaths per 100,000 men).

The prevalence of the illnesses and diseases presented in Table 1 and Table 2 can be reduced through regular physical activity. This section provides a summary of research on the associations between physical activity and specific health indicators. Researchers often classify physical activity into four levels of intensity: inactive, light activity, moderate activity, and high activity. These physical activity levels are grouped by a standard measure of energy expenditure called the Metabolic Equivalent of Task (MET). MET describes how much energy a person is expending during an activity relative to how much energy that

Table 1: Female Crude Mortality Rates per 100,000 Population by Age (CDC Wonder, 2017)

AGE	ILLNESSES & DISEASES									ALL CAUSES
	CANCER			CARDIO-VASCULAR		RESPIR-ATORY (F)	MENTAL ILLNESS		OTHER	
	BREAST (A)	COLOR-ECTAL (B)	LUNG (C)	STROKE (D)	HEART DISEASE (E)		DEMENTIA (G)	DEPRE-SSION (H)	DIABETES (I)	
00-04 years	0.0*	0.0*	0.0*	0.0*	0.0*	0.0*	0.0*	0.0*	0.0*	146.7
05-14 years	0.0*	0.0*	0.0*	0.0*	0.0*	0.0*	0.0*	0.0*	0.0*	13.6
15-24 years	0.0*	0.0*	0.0*	0.0*	0.0*	0.0*	0.0*	0.0*	0.0*	53.8
25-44 years	5.8	1.9	3.7	0.0*	7.9	2.6	0.0*	0.0*	3.5	161.7
45-54 years	26.6	9.0	25.0	3.8	28.3	15.5	0.0*	0.0*	12.6	384.1
55-64 years	40.6	14.8	79.1	9.6	73.2	60.1	3.5	3.7	33.1	791.7
65-74 years	75.9	37.5	160.3	25.6	171.1	160.2	32.5	28.5	72.0	1,694.9
75+ years	137.1	87.1	241.0	273.9	929.9	462.9	748.4	684.3	177.1	7,754.6

** Values suppressed in CDC Wonder dataset due to small sample sizes.*

(A) Malignant neoplasm of breast; (B) Malignant neoplasm of colon; (C) Malignant neoplasm of bronchus and lung; (D) Stroke, not specified as hemorrhage or infarction; (E) Ischemic heart disease; (F) Chronic lower respiratory diseases; (G) Alzheimer disease and vascular or unspecified dementia; (H) Depressive episode and recurrent depressive disorder; (I) Diabetes mellitus

person is using while at rest. For example, 1 MET-hour can be achieved while sitting for an hour or 4 MET-hours can be achieved while casually bicycling for an hour. Table 3 shows the relationship between the four levels of physical activity and MET expenditures.

Table 2: Male Mortality Rates per 100,000 Population by Age (CDC Wonder, 2017)

AGE	ILLNESSES & DISEASES									ALL CAUSES
	CANCER			CARDIOV-ASCULAR		RESPIR-ATORY (F)	MENTAL ILLNESS		OTHER	
	BREAST (A)	COLOR-ECTAL (B)	LUNG (C)	STROKE (D)	HEART DISEASE (E)		DEMENTIA (G)	DEPRE-SSION (H)	DIABETES (I)	
00-04 years	0.0*	0.0*	0.0*	0.0*	0.0*	0.0*	0.0*	0.0*	0.0*	178.3
05-14 years	0.0*	0.0*	0.0*	0.0*	0.0*	0.0*	0.0*	0.0*	0.0*	16.9
15-24 years	0.0*	0.0*	0.0*	0.0*	0.0*	0.0*	0.0*	0.0*	1.5	131.2
25-44 years	0.0*	4.4	3.1	1.7	12.3	1.8	0.0*	0.0*	5.4	312.2
45-54 years	0.0*	11.1	31.5	3.6	77.6	12.9	0.0*	0.0*	21.2	609.6
55-64 years	0.0*	19.5	115.2	12.1	206.7	66.4	3.8	3.1	50.6	1,284.5
65-74 years	0.0*	44.1	232.6	35.5	377.7	182.9	34.2	23.9	109.6	2,465.8
75+ years	0.0*	111.3	424.3	211.7	1,382.9	551.4	525.5	423.6	239.7	8,676.9

** Values suppressed in CDC Wonder dataset due to small sample sizes.*

(A) Malignant neoplasm of breast; (B) Malignant neoplasm of colon; (C) Malignant neoplasm of bronchus and lung; (D) Stroke, not specified as hemorrhage or infarction; (E) Ischemic heart disease; (F) Chronic lower respiratory diseases; (G) Alzheimer disease and vascular or unspecified dementia; (H) Depressive episode and recurrent depressive disorder; (I) Diabetes mellitus

Table 3: Levels of Physical Activity*

PHYSICAL ACTIVITY INTENSITY	MET	EXAMPLES
Inactive (sedentary)	1 MET-hour	Reclining or sitting yields 1 MET-hour
Light-intensity activity	<3 MET-hours	Light gardening yields 2 MET-hours Walking slowly (<2 mph) yields 2 MET-hours
Moderate-intensity activity	3-5.9 MET-hours	Brisk walking yields 3.3 MET-hours Casual bicycling (<10 mph) yields 4 MET-hours Climbing stairs yields 4 MET-hours
High-intensity activity (vigorous)	≥6 MET-hours	Bicycling (10-16 mph) yields 6-10 MET-hours Strenuous hiking yields 6-7 MET-hours Running yields 13.5 MET-hours

**Sources: American Institute of Cancer Research (2018) and Harvard (2009)*

Cancer

Cancer is the second most common cause of age-adjusted death in Ohio and across the United States, accounting for nearly one of every four deaths (Ohio Department of Health, January 2019). Lung and bronchus, colorectal (colon and rectum), and breast cancers are among the most common and are the most fatal cancers in Ohio (Ohio Department of Health, January 2019). There are specific factors that increase an individual's risk of having cancer, including exposure to or consuming carcinogens, being sedentary, and being overweight or having obesity. Engaging in physical activity is shown to significantly reduce the risk of being diagnosed with and potential of dying from one of these cancers (American Institute of Cancer Research, 2018; Lemanne, 2013).

Overwhelmingly, **lung and bronchus cancer** was the leading cause of age-adjusted cancer related deaths in Ohio in 2016, accounting for 28% of all cancer deaths (Ohio Department of Health, January 2019). While smoking is known to contribute the greatest risk for developing lung cancer, physical activity is associated with a reduced risk of lung cancer in the general population (Tardon, 2005) even among those who smoke (Buffarta, 2014). Additionally, ambient exposure to traffic emissions is significantly associated with increased risk of and mortality from lung cancer, especially among individuals who spend large quantities of time in traffic (e.g., professional drivers) exposed to vehicular emissions (Chen, 2015).

Colorectal cancer is the fourth most diagnosed cancer in Ohio and is the second leading cause of age-adjusted cancer deaths at 9% (Ohio Department of Health, January 2019). Strong and consistent evidence supports that being physically active can protect against colon cancer (American Institute of Cancer Research, 2018), although a dose-response relationship has not been established. There is no conclusion within the available research on the relationship between physical activity and rectal-specific cancer excluding the colon (American Institute of Cancer Research, 2018).

Breast cancer is the most commonly diagnosed cancer and the third most fatal in Ohio, making up 15% of the state's cancer diagnoses and 7% of all cancer deaths according to 2016 data (Ohio Department of Health, January 2019). There is strong evidence that being physically active significantly decreases the risk of breast cancer, in addition to breastfeeding, limiting alcoholic drink consumption, and not having obesity or being overweight (American Institute of Cancer Research, 2018). All physical activity provides a dose-response association with post-menopausal breast cancer, where more physically activity women experience the greatest reduction in risk for breast cancer (American Institute of Cancer Research, 2018; Janet, 2013). For premenopausal individuals, high-intensity physical activity, rather than moderate or low intensity, is most strongly associated with reduced breast cancer risk (American Institute of Cancer Research, 2018).

Stroke

Stroke is the 11th leading cause of death in Ohio, with 22.7 age-adjusted deaths per 100,000 people in 2017 (Ohio Public Information Warehouse). Stroke has been shown to be more prevalent in individuals experiencing hypertension, type 2 diabetes, obesity, cigarette smoking, heart disease, and physical inactivity (National Heart, Lung, and Blood Institute). Research over the past decades has established that the full range of physical activity, from light to high, can help reduce cardiovascular risk factors associated with stroke for both ischemic (clot) and hemorrhagic (bleeds), assist in stroke rehabilitation, and help prevent stroke recurrence (Gallanagh, 2011). A dose-response meta-analysis found physical activity decreases risk for ischemic stroke by a maximum of 26%, with the greatest risk reduction found in shifting from inactive to light activity (Kyu, 2016). Compared with inactive individuals (<10 MET-hours per week), individuals who incorporate light physical activity (10-67 MET-hours per week) see a 16% reduction in their risk of stroke, moderate activity individuals (67-133 MET-hours per week) see a 19% risk reduction, and high activity individuals (≥133 MET-hours per week) see a 26% risk reduction (Kyu, 2016).

Heart Disease

Heart disease, also called cardiovascular disease, refers to a range of conditions affecting the heart and vascular system, such as coronary artery disease (CAD), arrhythmias, and congenital heart defects. Chronic ischemic heart disease is the leading cause of death in Ohio, with 71.1 age-adjusted deaths per 100,000 people in 2017 (Ohio Public Information Warehouse). And hypertensive heart disease is the 21st leading cause of death in Ohio, with 15.2 age-adjusted deaths per 100,000 people in 2017 (Ohio Public Information Warehouse). Many heart diseases are considered preventable through modification of environmental factors and behaviors, such as access to recreation facilities and engagement in physical activity. Physical activity provides a dose-response risk reduction of heart disease, along with slowing the detrimental effects of heart disease among diagnosed patients and preventing recurrence, with a stronger association among women (Alves, 2016). A meta-analysis of heart disease research shows evidence that individuals who engage in 150 minutes/week or more of moderate physical activity benefit from a 15-20% lower risk of developing CAD compared to individuals who are inactive (Sattelmair, 2011; Alves, 2016). Even if an individual cannot met this threshold of physical activity, evidence supports that even low levels of physical activity can help reduce the risk of heart disease (Sattelmair, 2011).

Asthma

Asthma is a chronic disease that affects the airways in the lungs and causes inflammation that leads to repeated episodes of wheezing, breathlessness, and coughing. Asthma poses a serious health and economic concern in Ohio, with 11% of children and 14% of adults reporting having been diagnosed with asthma at some point during their lives (CDC, BRFSS, 2017). In addition, racial disparities exist in the prevalence of asthma, with black adults and children in Ohio experiencing significantly higher prevalence of the condition and higher mortality rates compared to white adults and children (Ohio Department of Health, April 2019). Asthma and physical activity have a complex relationship. Engaging in physical activity is associated with a reduced severity of asthmatic symptoms (Lang, 2004), but individuals with asthma may limit their physical activity due to fear of triggering any symptoms (Walker, 2014). As a result, children and adults with asthma are more likely to be overweight or have obesity (Jones, 2006).

Dementia

Dementia is the term used to describe numerous conditions associated with a decline in memory or other cognitive abilities to perform one's daily activities. Alzheimer's disease is a dementia that accounts for 60-80% of dementia cases, and it is the 5th leading cause of death in Ohio, with 43.9 age-adjusted deaths per 100,00 people in 2017 (Ohio Public Information Warehouse). Evidence supports physical activity as one strategy to prevent the onset of dementia, as it has been shown to help reduce the risk of dementia (Hamer, 2008). For every 10 MET-hours per week increase in physical activity, a meta-analysis study found a 10% reduced risk for all-cause dementia and 13% reduced risk for Alzheimer's disease (Xi, 2017).

Depression

Depression is associated with numerous chronic diseases, whether as a precursor to or an effect of having a chronic disease. Having depression worsens an individual's overall health outcome, for individuals with no additional health conditions and for those with existing health conditions (Moussavi, 2007). According to Substance Abuse and Mental Health Services Administration, the prevalence of depressive episodes among Ohio adolescents (aged 12-17) gradually increased between 2011-2012 and 2014-2015 from 8.9% to 11.9%, which is consistent with national trends (2015). Risk factors associated with depression include personal or family history of depression, major life changes, trauma, and stresses, and certain physical illnesses and medications. Longitudinal studies have shown that various levels of physical activity have a dose-response effect on the prevalence of depression, with even low levels of activity such as walking less than 150 minutes/week protecting against depression (Mammen, 2013; Teychenne, 2008).

Diabetes

Type 2 Diabetes is a chronic disease in which blood glucose levels (sugar levels in the blood) are above normal due to a malfunction in the insulin regulation of the pancreas. The health risks associated with diabetes can be quite serious and include heart disease, stroke, blindness, kidney disease, high cholesterol, and permanent lower-extremity nerve damage (Wu, 2014), and diabetes mellitus is the 8th leading cause of death in Ohio, with 32.1 age-adjusted deaths per 100,000 people in 2017 (Ohio Public Information Warehouse). While there are a number of genetic factors that contribute to a person's risk of developing diabetes, there are also many modifiable factors that a person can control to prevent the disease, including physical inactivity (Wu, 2014). Meta-analyses show a strong inverse association with physical activity and risk of type 2 diabetes, with a steeper reduction in risk for individuals who incorporate light to moderate physical activity compared to individuals engaging in high levels of activity (Aune, 2015; Kyu, 2016). Compared to sedentary individuals, those who achieved low activity levels (10 MET-hours per week) saw a 2% lower risk of diabetes, those who achieved moderate activity (10 - 60 MET-hours per week) saw a 19% lower risk, and those who achieved high activity (≥133 MET-hours per week) saw a 28% lower risk (Kyu, 2016).

TRAFFIC INJURIES

While increased physical activity through walking and bicycling can help reduce the prevalence of some illnesses and diseases, it may also contribute to increased traffic-related injuries or a shift in traffic-related injuries from other modes. The primary factors leading to the traffic injuries may include traveler behavior (e.g., speeding, distractions, and/or driving under the influence) or infrastructure design (CDC, 2017). While a greater number of walking and bicycling trips may provide increased perceptions of safety ("strength in numbers"; Jacobsen, 2003), the increased number of individuals engaging in active transportation when no safety infrastructure improvements have been made can often result in additional traffic injuries (Nicolas, 2019). These injuries may be preventable and can be reduced through well-designed infrastructure, signage, vehicular controls, and heightened awareness.

ITHIM FRAMEWORK

In 2009, a team of researchers developed an Integrated Transport and Health Impact Modelling Tool (ITHIM) that can be used to measure the health impacts of increases in bicycling, walking, and transit. ITHIM compares changes in risk of cancer, stroke, depression, diabetes, heart disease, and other morbidities associated with a lack of physical activity and exposure to air pollution. This comparative change is then converted into a single measure of overall disease burden, called disability-adjusted life years, or DALYs. This single measure represents the estimated number of years of life that a population might lose due to poor health, disability, or pre-mature death of its members. DALYs is used by health professionals because it allows for comparisons of health outcomes across different counties, states, and countries. Figure 1 shows the framework used in ITHIM.

There are 13 primary inputs to ITHIM that are derived from travel and health surveys, travel demand and air pollution models, and administrative data on mortality, burden of disease, and road traffic injuries (see Table 4). The technical report for ITHIM calibration provides detailed descriptions of the data sources and processing steps for the inputs (Maizlish, 2013).

Figure 1: ITHIM Framework (CEDAR)

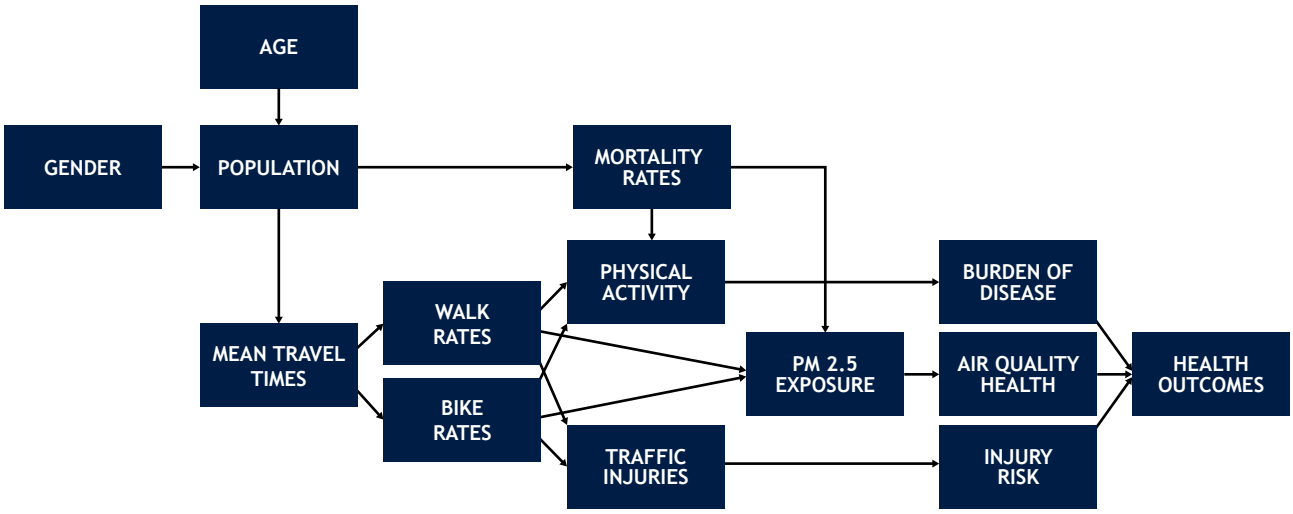


Table 4: ITHIM Parameters and Strata

PARAMETER	UNIT	STRATA	SOURCE
Per capita mean daily travel distance	Mi/person/day	Age, gender, mode	NHTS (2017)
Per capita mean daily travel time	Min/person/day	Mode	NHTS (2017)
Ratio of per capita mean daily active travel time (relative to females aged 15-29)	N/A	Mode	NHTS (2017)
Standard deviation of mean daily active travel time	Min/person/day	Mode	NHTS (2017)
Distribution of population	Percent	N/A	ACS (2013-2017)
Age-sex ratio of disease-specific rate between study area and United States	N/A	Age, gender	CDC Wonder (2017)
Proportion of colon cancers from all colorectal cancers	N/A	N/A	CDC Wonder (2017)
Walk speed	Mph	Mode	Oberg (1993)
Per capita weekly non-travel related physical activity	MET-hours/week	Age, gender	BFRSS (2017)
CO2 emitted by distanced traveled	lbs/mi	N/A	EMFAC (2014
Emissions of primary and secondary sources of PM2.5	Tons/day	N/A	EMFAC (2014)
Serious and fatal traffic injuries	Injuries	Mode	ODOT (2009-2018)
Ratio of daily per capita bicycling time to walking time	N/A	Mode	NHTS (2017)

Assumptions

The primary assumptions in ITHIM include:

- **Time**
  - The model assumes that the health co-benefits occur in a single "accounting year", although the changes in the physical activity distribution are likely to gradually occur over time.
  - The model assumes that disease rates and DALYs of the baseline do not vary over time
  - The model assumes that the distribution of baseline non-transport physical activity, PM2.5 levels, and traffic injury rates do not vary over time.
- **Physical Activity**
  - The model assumes an increase in physical activity due to active transportation is not compensated by a decrease in non-transport physical activity (no substitution effect).
  - The model assumes that other factors influencing physical activity and pollution levels are time invariant, including non-transport physical activity and body weight distributions.
- **Road Traffic Injuries**
  - The model assumes that "safety in numbers" occurs from increased walking and bicycling

Results

ITHIM uses "dose-response" relationships to estimate how incremental changes in the rates of physical activity among Ohio residents can impact the probability of residents experiencing select illnesses and diseases. For example, Figure 2 shows the dose-response relationship between physical activity (measured in MET-minutes per week) and the risk of heart failure (measured as a pooled hazard ratio) among adults. As physical activity levels increase, the risk of heart failure decreases. ITHIM uses similar dose-response relationships available in the literature to estimate the reduced risk of breast cancer, colorectal cancer, lung cancer, stroke, heart disease, lower respiratory disease, dementia, depression, and diabetes as physical activity levels increase. The model estimates individual dose-response relationships for various age groups by sex and incorporates Ohio-specific mortality data shown in Table 1 and Table 2.

Figure 2: Dose-response Relationship between Physical Activity and Heart Failure (Pandey, et al., 2015)

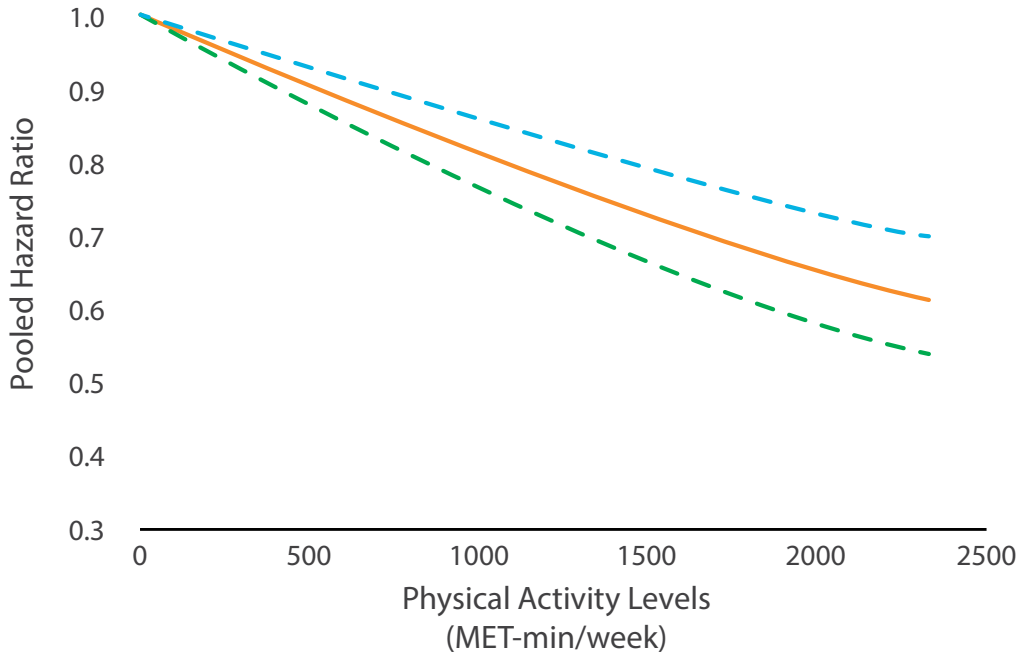
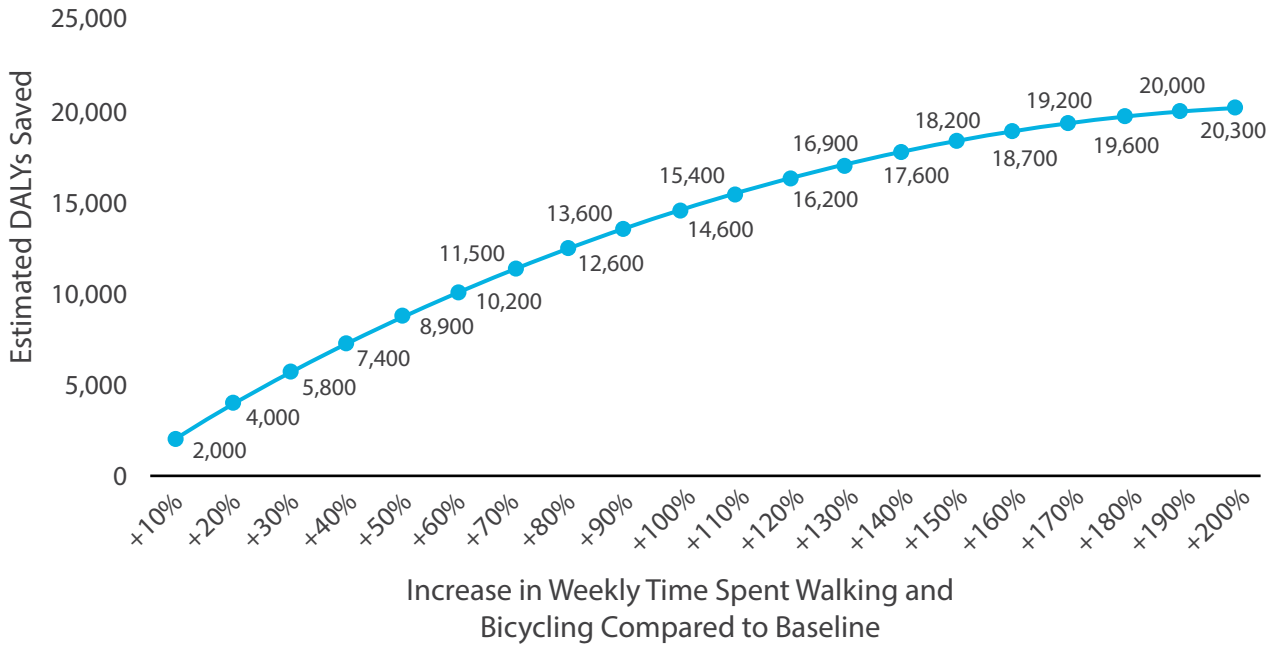


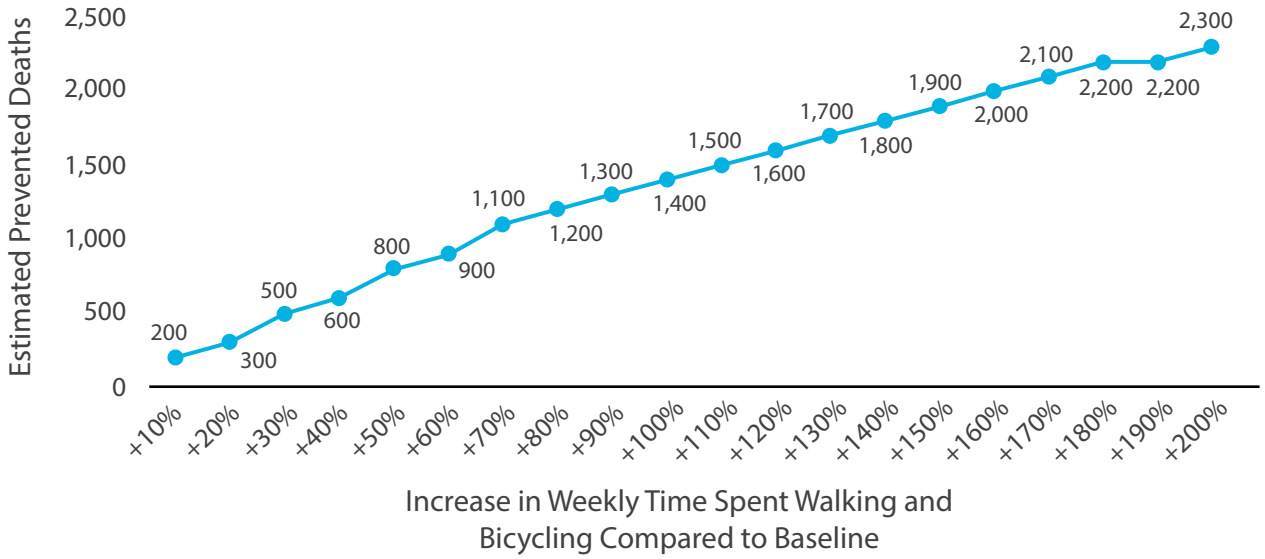
Figure 3: Estimated DALYs Saved with Increased Physical Activity



Using the estimated dose-response relationships for selected illnesses and diseases, Figure 3 shows the potential savings of DALYs from sustained increased physical activity over the baseline rate. The figure shows that as physical activity rates increase, the potential for longer, healthier lives among Ohio residents also increases but with diminishing marginal utility. The model estimates that a 10% increase in physical activity from walking and bicycling in Ohio could save 2,000 DALYs per year, a 50% increase could save 8,900 DALYs per year, and a 100% increase could save 13,600 DALYs per year. Stated another way, all things being equal, a 10% sustained increase in physical activity from walking and bicycling in Ohio could help prolong the lives of Ohio residents by approximately 2,000 disability-free years, a 50% sustained increase could prolong 8,900 disability-free years, and a 100% sustained increase could prolong 14,600 disability-free years.[1]

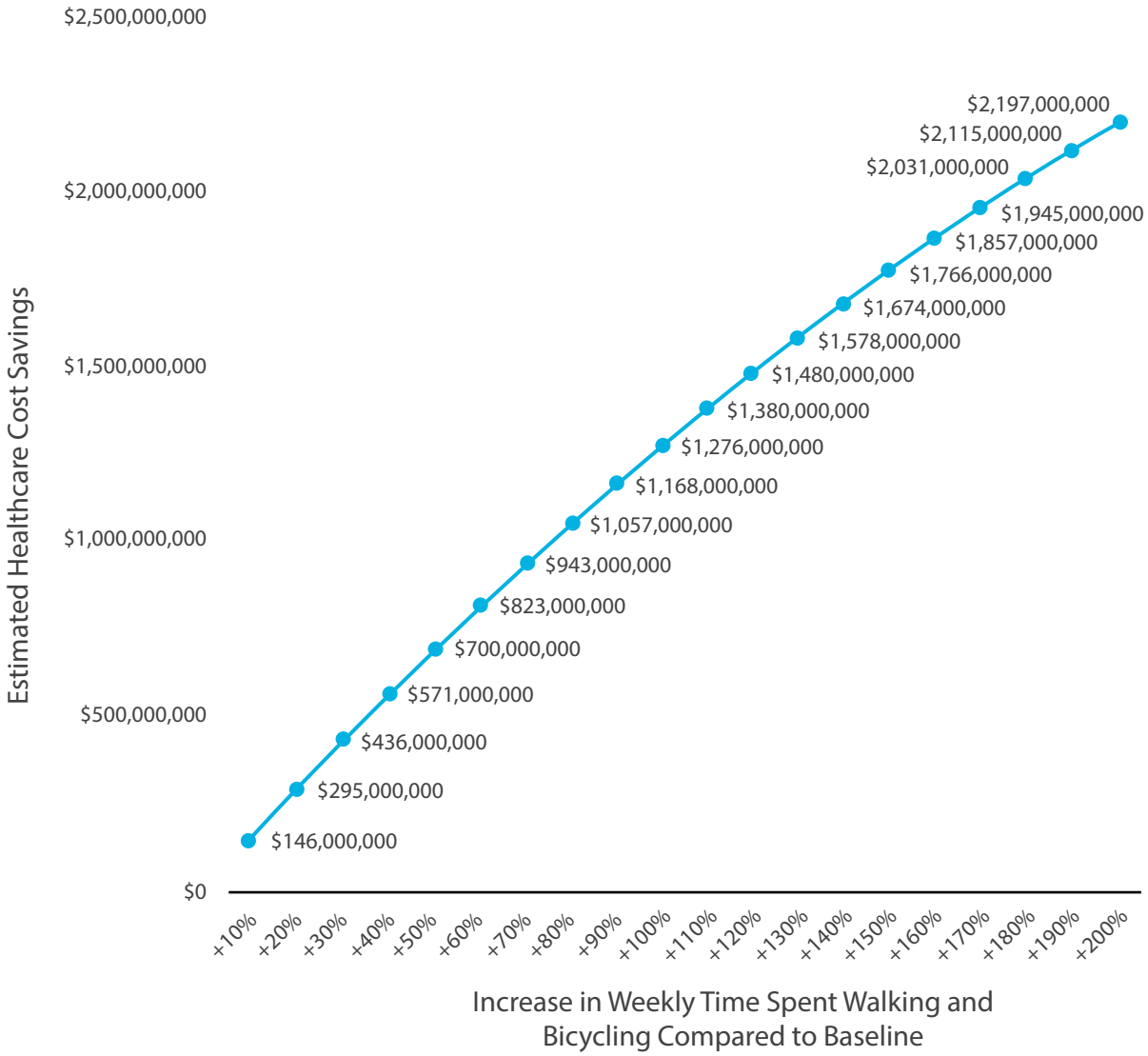
[1] *For more information on the methods included in ITHIM, see Maizlish, N., Linesch, N.J., and J. Woodcock. Health and greenhouse gas mitigation benefits of ambitious expansion of cycling, walking, and transit in California. Journal of Transport & Health. September 2017, 6: 490-500. < https://www.sciencedirect.com/science/article/pii/S2214140516302419>*

Figure 4: Estimated Prevented Deaths with Increased Physical Activity



Translating DALYs to preventable deaths, Figure 4 shows how a sustained increase in physical activity over the current baseline could help prevent premature mortalities. The figure shows that as the physical activity rate increases, the potential for preventing premature deaths increases but with diminishing marginal utility. The model estimates that a 10% sustained increase in physical activity from walking and bicycling in Ohio could prevent 200 pre-mature deaths, a 50% sustained increase could prevent 800 deaths, and a 100% sustained increase could prevent 1,400 deaths.

Figure 5: Estimated Healthcare Cost Savings with Increased Physical Activity (10% Increments)



Using national cost of illness data from available literature, Figure 5 (10% increments) and Figure 6 (5% increments) show the potential healthcare cost savings associated with a sustained increase in physical activity from walking and bicycling. The figures show that as the physical activity rate increases, the potential for healthcare cost savings increases but with diminishing marginal utility. The model estimates that a 10% sustained increase in physical activity from walking and bicycling in Ohio could save the State $146 million in healthcare expenditures, a 50% sustained increase could save $700 million in healthcare expenditures, and a 100% sustained increase could save $1,276 million in healthcare expenditures.

Figure 6: Estimated Healthcare Cost Savings with Increased Physical Activity (5% Increments)

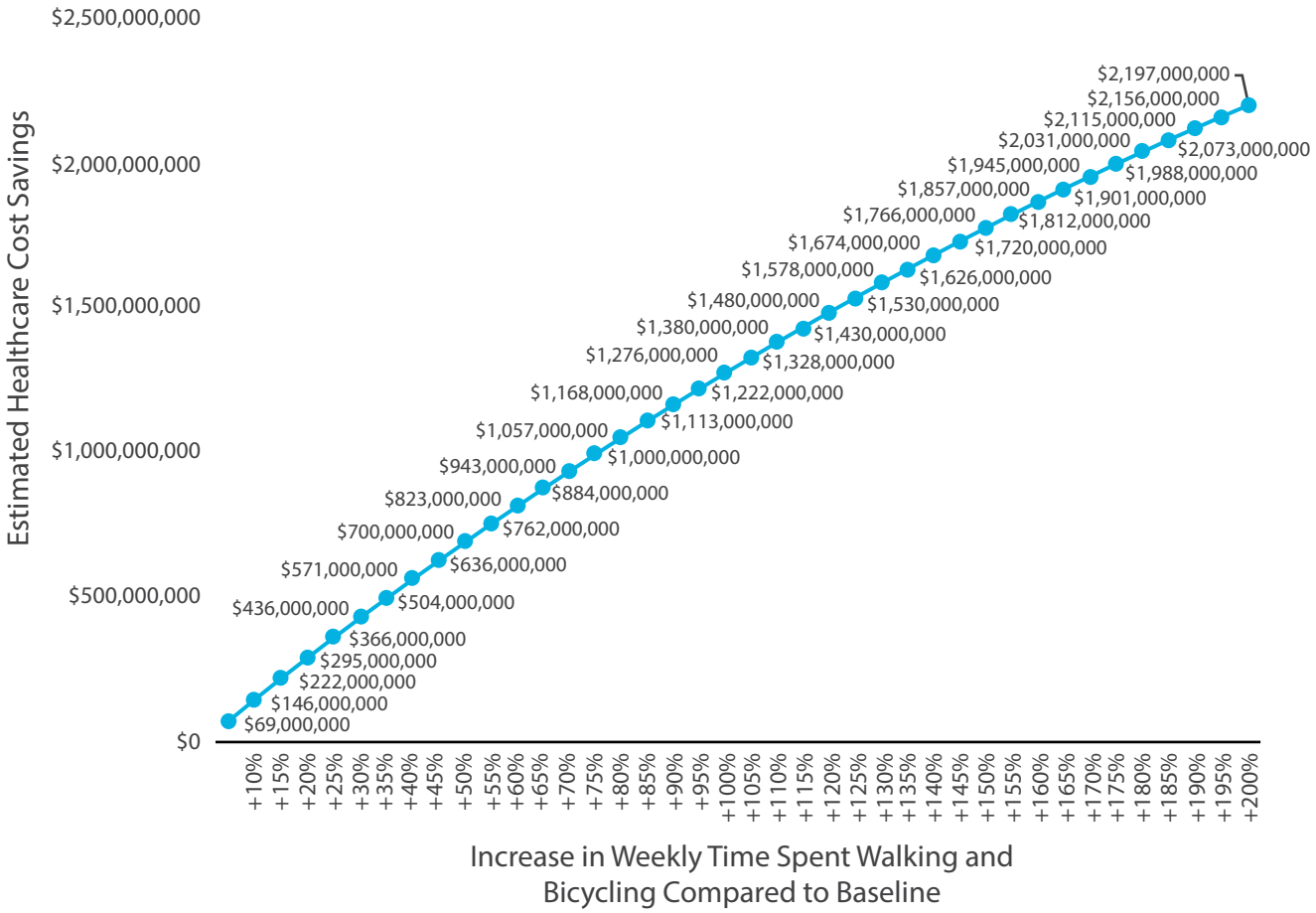


Table 5: Estimated Healthcare Cost Savings with Increased Physical Activity (5% Increments)

INCREASE IN PHYSICAL ACTIVITY	ESTIMATED HEALTHCARE COST SAVINGS	INCREASE IN PHYSICAL ACTIVITY	ESTIMATED HEALTHCARE COST SAVINGS
+5%	$69,000,000	+105%	$1,328,000,000
+10%	$146,000,000	+110%	$1,380,000,000
+15%	$222,000,000	+115%	$1,430,000,000
+20%	$295,000,000	+120%	$1,480,000,000
+25%	$366,000,000	+125%	$1,530,000,000
+30%	$436,000,000	+130%	$1,578,000,000
+35%	$504,000,000	+135%	$1,626,000,000
+40%	$571,000,000	+140%	$1,674,000,000
+45%	$636,000,000	+145%	$1,720,000,000
+50%	$700,000,000	+150%	$1,766,000,000
+55%	$762,000,000	+155%	$1,812,000,000
+60%	$823,000,000	+160%	$1,857,000,000
+65%	$884,000,000	+165%	$1,901,000,000
+70%	$943,000,000	+170%	$1,945,000,000
+75%	$1,000,000,000	+175%	$1,988,000,000
+80%	$1,057,000,000	+180%	$2,031,000,000
+85%	$1,113,000,000	+185%	$2,073,000,000
+90%	$1,168,000,000	+190%	$2,115,000,000
+95%	$1,222,000,000	+195%	$2,156,000,000
+100%	$1,276,000,000	+200%	$2,197,000,000

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