Climate Smart Strategy

Health Impact Assessment

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Prepared by:
Nicole Iroz-Elardo, Ph.D.
Policy Analyst, Healthy Communities Lab

Andrea Hamberg, B.A.
Program Coordinator, Healthy Communities Lab

Eric Main, A.I.C.P.
GIS Analyst, EHPT

Brendon Haggerty, M.U.R.P.
Epidemiologist, Climate and Health Program

Julie Early-Alberts, M.S.
Manager, Healthy Communities Unit, Environmental Public Health

Curtis Cude, B.S.
Principal Investigator and Interim Section Manager, Environmental Public Health

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ACRONYMS

BRFSS	Behavioral Risk Factor Surveillance System
CCC	Community Climate Choices
COI	cost of illness
CSCS	Climate Smart Communities Scenarios
CSS	Climate Smart Strategy
DALY	disability adjusted life years (sum of YLL and YLD)
DEQ	Oregon Department of Environmental Quality
GHG	greenhouse gas
GreenSTEP	Greenhouse Gas Strategic Transportation Energy Planning Model
HIA	Health Impact Assessment
ITHIM	Integrated Transport and Health Impact Model
LDV	light-duty vehicle (gasoline powered)
ODOT	Oregon Department of Transportation
OHA-PHD	Public Health Division of the Oregon Health Authority
PATS	Portland Air Toxics Solutions
VMT	vehicle miles traveled
WHO	World Health Organization
YLD	years of life with a disability
YLL	years of life lost

EXECUTIVE SUMMARY

As mandated by the 2009 Oregon Legislature, the Metro regional government is assessing options for reducing greenhouse gas (GHG) emissions in the Portland metropolitan area. This health impact assessment (HIA) found that the investments in land use and transportation systems under consideration not only protect health by reducing the risks of climate change, they may also improve the region's health by increasing physical activity, reducing traffic collisions, and improving air quality.

The Healthy Communities Lab in the Oregon Health Authority's Public Health Division (OHA-PHD) used the Integrated Transport and Health Impact Model (ITHIM) to assess the extent to which the Climate Smart Draft Approach is expected to increase physical activity, reduce exposure to air pollutants, and prevent traffic collisions. **Model results estimate that by 2035 the Draft Approach avoids 126 premature deaths and reduces illness by 1.6% annually.**

Physical inactivity is a leading risk factor for deadly health burdens in our region. Exercising at least 150 minutes a week prevents chronic diseases and can add up to four years in life expectancy, but only half of all Oregonians meet that goal. Chronic diseases are costly. More than $1.5 billion is spent each year on cardiovascular disease in the region; $623 million each year is borne by taxpayers in Medicaid and Medicare payments.

Transportation choices allow people to routinely and flexibly integrate physical activity into their lives. These choices depend on a well-functioning and safe transportation system for all types of users throughout the region. Evidence shows that land-use elements of residential density, land-use mix, number of nearby community destinations and street connectivity are particularly effective at removing barriers to walking, biking and use of transit. Complete streets may be the most health-promoting aspect of the investments and actions being considered.

The Draft Approach is expected to reduce illness linked to physical inactivity by as much as 1.3% and avoid up to 61 premature deaths each year from increased active transportation. Chronic conditions due to physical inactivity are some of the most costly health burdens our region faces. For example, the Center for Disease Control and Prevention (CDC) Chronic Disease Cost Calculator v2.0 suggests the three-county area spends $1.5 billion (2010 dollars) annually on cardiovascular-related illness which is significantly linked to insufficient physical activity.

Increasing the number of people who regularly exercise by choosing to walk or bike to the library, school, work, church or the store can improve our region's health, reduce premature deaths and lower health care costs.

The scenarios considered, including the Draft Approach, achieve GHG emissions goals, in part, by lowering per capita vehicle miles traveled (VMT). As people travel shorter distances, overall traffic risk is reduced resulting in fewer overall traffic fatalities (5.1%) and severe injuries (6.7%).

Due to the increase in miles traveled using active transportation modes, ITHIM shows that the absolute numbers of pedestrian and bicycle collisions will increase even as the overall rate decreases. Finally, lower per capita VMT combined with technological advances in fuels suggests that illness linked with air quality as measured by fine particulate matter ($PM_{2.5}$) will improve by at least 2.5% and prevent 59 premature deaths each year.

INTRODUCTION

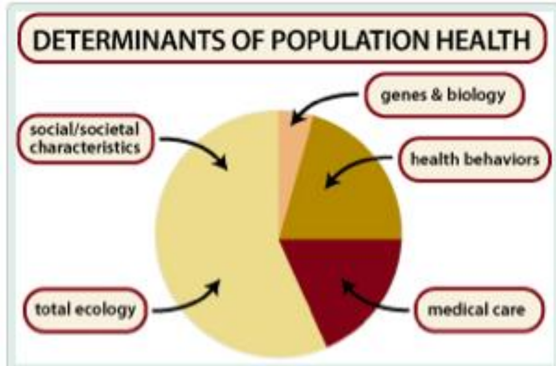

Figure 2. Social and Environmental Determinants of Health

Our health and well-being is influenced by many individual level factors: who our parents are, the food we eat and access to health care. But health is more than genes and personal choices; the places we live, work and play have a significant impact on our health. For example, access to sidewalks and community destinations impact how much we walk and living close to major roads and freeways increases our risk for chronic diseases such as asthma and cardiovascular disease. The field of public health calls these greater influences the social and environmental determinants of health (1, 2) (**Figure 1**).

Significant shifts in the climate are already happening, and as the climate continues to warm the impacts to health will become more apparent (3). As shown in The Oregon Climate and Health Profile Report, Oregon will likely experience more frequent heat waves, an increase in asthma and other respiratory diseases, changes in disease patterns, and diminishing water quality and quantity (4). Curbing climate change is a pressing public health issue, and the U.S. Environmental Protection Agency and the Centers for Disease Control and Prevention (CDC) support efforts across the nation to protect health by reducing greenhouse gas emissions (3). Addressing climate change requires work across sectors. This cross-sectoral work affects social and environmental determinants of health such as transportation and community design.

The 2009 Oregon Legislature required the Portland metropolitan region to develop a plan to reduce per capita greenhouse gas emissions (GHG) from cars and small trucks by 20 percent below 2005 levels by 2035. To meet this GHG emission reduction target, Metro’s Climate Smart Communities Scenarios (CSCS) project used regional scenario planning over the past four years to evaluate and discuss a range of technological improvements, education programs, and land use and transportation investments intended to reduce emissions and lower average vehicle miles traveled (VMT) by the region’s cars and small trucks. The CSCS Project is focused on meeting the emission reduction target by supporting land use patterns where jobs, services and shopping are located near where people live; improving transit service; using technology to manage traffic flow; and building a well-connected network of complete streets including providing safer routes for walking and biking.

While the primary goal of the CSCS project is to address the GHG reduction mandate, Metro is also considering impacts on the economy, the environment, public health and equity. Metro has partnered with the Healthy Communities Lab in the Environmental Public Health Section of Oregon Health Authority’s Public Health Division (OHA-PHD) to understand the health implications of each scenario. The Environmental Public Health Section's Healthy Communities Lab is home to the Health Impact Assessment Initiative.

Health impact assessment (HIA) provides decision-makers with information about how a proposed policy, program or project may affect the health of people. HIA differs from traditional public health assessment in several ways: the health impacts of a proposal are assessed before a final decision is made, allowing the results of the HIA to be considered in the decision-making process; the assessment is supported by robust stakeholder engagement; and the assessment is approached from a social determinants of health frame. HIA provides objective information that can be used to increase the positive health impacts of a project or policy and mitigate negative impacts.

The Climate Smart Strategy (CSS) HIA is the third in a series of HIAs to support the consideration of health in Metro's public conversation prior to Metro's final decision to select a GHG-reduction scenario in late 2014 (6, 7). The findings and recommendations of this HIA are intended to support the assessment by Metro and its partners of the Draft Approach in comparison to the three scenario options assessed in the Community Climate Choices HIA earlier this year. This should, in turn, inform the finalization and adoption of a Final Preferred Scenario; help in prioritizing implementation; and guide monitoring of successful improvements in key determinants of the health of the region's communities.

METHODOLOGY

HIA is guided by practice standards established by the Society of Practitioners of Health Impact Assessment (SOPHIA) known as the HIA Minimum Elements. This HIA adheres to the HIA Minimum Elements established by SOPHIA's North American HIA Practice Standards Working Group (Appendix B) (8).

Metro appreciated the data and analysis provided in previous HIAs on decisions within the Climate Smart Communities Scenario Planning project, but did not have the expertise necessary to conduct a health assessment on the Draft Approach. Metro requested support from OHA-PHD's Healthy Communities Lab staff, and OHA-PHD agreed to conduct this HIA project in consultation with Metro Climate Smart Communities Project staff in July 2014.

Policy Parameters

Metro's Climate Smart Communities Project assumes GHG reduction through transportation and land use strategies and investments. In particular, Metro has been mandated to study reduction of GHG from reduced emissions from light-duty (gasoline) cars and trucks. While diesel (mobile and stationary) account for a significant portion of GHG in the region, both the Climate Smart Communities Project and this HIA are focused only on light-duty vehicles.

Metro defined the horizon year as 2035 and the geographic boundary as the 2010 Urban Growth Boundary (UGB). This HIA adopted these parameters. Exceptions, such as health information not available for the UGB but rather for metropolitan statistical areas (MSAs), are clearly noted throughout the report.

This HIA focuses on the Climate Smart Draft Approach – the policy package under current consideration – with comparisons to previously studied scenarios. This approach was chosen because Metro councilors are expected to continue to refine the combination of strategies and investments until adoption of a final preferred approach. Specifically, the Draft Approach is compared to updated modeling results for Scenarios A, B and C from the Community Climate Choices (CCC) HIA. Scenario A assumes continuation of current investment levels. Scenario B assumes the implementation of all adopted plans, which would require increased revenues from existing sources. Scenario C expands Scenario B with additional policy and infrastructure investments including identifying new funding sources. The Draft Approach under consideration combines elements of Scenarios B and C including full implementation of the adopted 2014 Regional Transportation Plan with additional investment in transit; lower-cost transportation system management and operations (TSMO); and lower-cost information and incentive strategies.

Stakeholder Engagement

Because this HIA is an extension of previous work, the scope of this HIA was informed by feedback from the existing advisory committee used to oversee the past two HIAs. OHA-PHD adopted the previous scope of the CCC HIA with the following changes: the comparison was modified to include the Draft Approach in addition to Scenarios A, B, and C; the analysis was extended to include the Portland metropolitan region's climate change risks; air pollution risks in the region were expanded to include near-roadway information; and monetary information about costs associated with prevented illness and deaths by pathway was added. The advisory committee (Appendix A) provided feedback on the draft scope early in the HIA. OHA-PHD convened members of the committee for discussions on air quality, monetization methods and changes to ITHIM calculations. Volunteers from the committee reviewed the report and recommendations before it was publically released. More information about stakeholder participation can be found in Appendix C.

Existing Health Conditions and Pathways

OHA-PHD used state and federal databases such as the Behavioral Risk Factors Surveillance Survey (BRFSS) to document current prevalence and incidence rates of conditions and behaviors associated with the pathways of interest (9, 10). In this HIA, the state of the science for pathways of interest was assessed with an in-depth literature review. The Healthy Communities Lab maintains a robust and growing database of over 600 journal articles, scientific reports and government guidance linking the built environment to health. OHA-PHD verified the findings and expanded the assessment with expert review, including support from OHA-PHD's Climate and Health Program, OHA-PHD's Injury and Violence Prevention Program, OHA-PHD's Health Promotion and Chronic Disease Prevention Program, the Oregon Department of Environmental Quality, the Oregon Department of Transportation, the Near-Roadway Section of the US Environmental Protection Agency, and staff and partners at Metro.

Integrated Transport and Health Impact Model (ITHIM)

To quantitatively predict how the Climate Smart Draft Approach might impact selected health pathways, OHA-PHD used the Integrated Transport and Health Impact Model (ITHIM) tool (11, 12). ITHIM was developed at the University of Cambridge by Dr. James Woodcock and has been used in transportation and climate applications worldwide including by OHA-PHD and the California Department of Public Health. ITHIM uses current burden of disease estimates (in this application, derived from Oregon-level vital statistics for 2008-2010 (13, 14)) and applies relative risks or odds ratios from the public health scientific literature to measures of expected changes in exposure. The result is estimated changes in mortality (deaths) and illness (as measured by disability adjusted life years or DALYs) by scenario in three main pathways: physical activity, traffic safety, and air quality as measured by fine particulate matter ($PM_{2.5}$). Outputs are reported as the difference between baseline (2010) and the scenario. Baseline and horizon years were set at 2010 and 2035 to match Metro's plan parameters. Conceptually, outputs are the expected number of avoided deaths and illness in the horizon year derived from current rates of exposure and associated disease burden.

This HIA updates ITHIM results contained within the CCC HIA for Scenarios A, B, and C because of two significant differences in the way air quality is accounted for within ITHIM, changes in assumptions about walking and cycling distances by age and gender, and changes addressing the age distribution for the horizon year (2035):

- OHA-PHD changed the baseline estimate of $PM_{2.5}$ concentrations from 6.6317 to 7.7291 $\mu g/m^3$. The air quality pathway of ITHIM is calculated by percent reduction in $PM_{2.5}$. In the previous HIAs, OHA-PHD used outputs from ODOT's GreenSTEP model for both baseline and scenarios: when compared to the monitored 2010 data, the GreenSTEP $PM_{2.5}$ outputs were reasonable. With the release of the 2012 monitored $PM_{2.5}$ it became apparent that 2010 was an artificially low year for $PM_{2.5}$. In this HIA, OHA-PHD used a 5-year average (2008-2012) of monitored data as baseline (15). Oregon DEQ maintains monitoring stations at Hare Field in Washington County and on SE Lafayette in Multnomah County to measure average urban levels in the region for National Ambient Air Quality Standards. Consistent with methodology and norms approved by the EPA, OHA-PHD assumed Multnomah County concentrations for Clackamas County. The monitored data was weighted by 2010 county population and averaged over the 5 years. This methodology was reviewed and approved by both Metro and DEQ staff at August 2014 meetings, and again during review of an early draft of this report.

- OHA-PHD added analysis of interactions between disease pathways. There are three diseases within ITHIM that capture both physical activity and air quality effects: stroke, ischemic heart disease, and hypertensive heart disease. In the CCC HIA, the percentage change in $PM_{2.5}$ was small enough that approximately 95% of the health effects in these pathways were attributable to physical activity and thus reported only as physical activity. With the larger percentage change in $PM_{2.5}$, approximately 40% of the mortality health benefits for these diseases are attributable to air quality. The change in baseline PM prompted parsing out the contributions of air quality and physical activity for each of these diseases for this HIA.

- OHA-PHD changed assumptions about how walking and cycling varies by age. Previous versions of ITHIM used European assumptions about which age groups would walk and cycle the most in both baseline and horizon years. This HIA set baseline assumptions using Oregon Household Activity Survey (16) and projected the horizon year (2035) using longitudinal data from the 1995, 2001, and 2009 National Household Travel Survey (17).

- OHA-PHD adjusted the horizon population for age. The previous HIAs held the age distribution of the population constant in both baseline and horizon years. This HIA used Oregon Office of Economic Analyses forecasts to appropriately adjust the age distribution of the population in the horizon year (2035).

ITHIM's burden-of-disease approach allows for the change in disease associated with changes in exposure to be isolated. It also facilitates comparisons across diseases and pathways to understand which changes in exposure maximize health. ITHIM does have a number of limitations. The model is limited to diseases with available vital statistics and high confidence in the literature of relative risks or odd ratios. ITHIM also relies on $PM_{2.5}$ as the only air quality indicator. ITHIM does not address design-level interventions and has difficulty characterizing air quality impacts at small spatial scales (near roadway). Finally, ITHIM does not facilitate analysis by race or income. For a more detailed discussion on ITHIM methodology and limitations, please see Appendix E in the CCC HIA (7).

Monetizing Health Benefits

A primary objective of this HIA was to provide decision-makers information on the cost savings associated with decreased illness and death. For this portion of the assessment, OHA-PHD utilized two widely accepted economic methodologies. First, expected decreases in disease were monetized using a top-down, attributable risk, cost-of-illness (COI) approach (18, 19). National COI values were identified within the literature for specific diseases modeled in ITHIM with preference for COI models from federal agencies or national medical associations. Additional COI amounts specific to Oregon were taken from the CDC's Chronic Debase Cost Calculator v2.0 (8). Each COI was proportionally reduced using population estimates within the Portland metropolitan region's Urban Growth Boundary (UGB) to represent the regional COI. The regional COI for each condition was then multiplied by the Draft Approach's "attributable fraction" as measured by the expected percent change in DALYs in ITHIM.

Second, deaths were monetized using a willingness-to-pay approach by applying the guidance value adopted by the U.S. Department of Transportation for the value of a statistical life (VSL) in 2013: $9.1 million (2012 dollars) per avoided death (18).

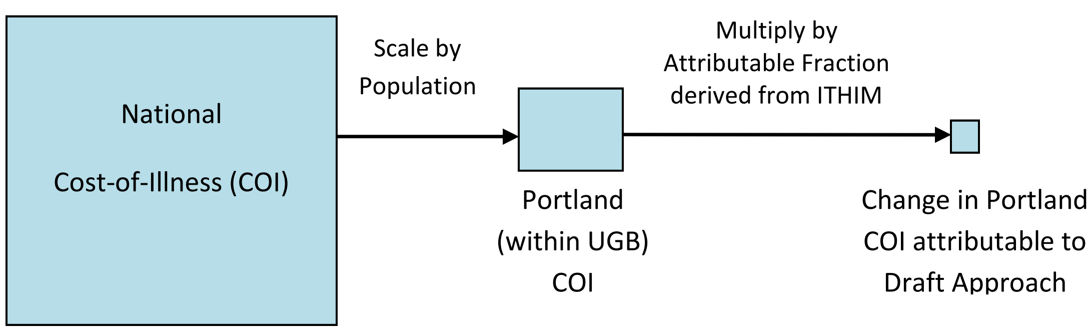

Figure 2. Change in Portland COI attributable to Draft Approach

CLIMATE AND HEALTH ASSESSMENT

The Third National Climate Assessment Report states the “global climate is changing and this is apparent across the United States in a wide range of observations. The global warming of the past 50 years is primarily due to human activities, predominantly the burning of fossil fuels” (3). In 2007, the Oregon State Legislature established climate change goals for the state to prevent and reduce the social, economic and environmental effects of global warming by meeting the greenhouse gas (GHG) emissions goals established by the United Nations Intergovernmental Panel on Climate Change. The Climate Smart Communities Scenarios Project was initiated by Metro in response to a state mandate connected to the 2007 Oregon legislation requiring the Portland metropolitan region to reduce per capita GHG emissions from cars and small trucks by 2035. More information on Oregon’s work to reduce and prepare for climate change can be found at the Oregon Global Warming Commission website: www.keeporegoncool.org.

Climate change threatens human health and well-being in many ways, including impacts from increased extreme weather events, wildfire, decreased air quality, threats to mental health, and illnesses transmitted by food, water, and disease-carriers such as mosquitoes and ticks. Some of these health impacts are already underway in the United States. Climate change will, absent other changes, amplify some of the existing health threats the nation now faces. Certain people and communities are especially vulnerable including children, the elderly, the sick, the poor and some communities of color (3, 20).

OHA-PHD's Climate and Health Program completed a Climate and Health Profile Report documenting the causal pathways by which climate change could impact health in Oregon(4). The report cites evidence of potential health impacts such as increases in heat-related illness, allergens, harmful algal blooms, vector-borne diseases, and respiratory illness from deteriorating air quality. Climate change could also increase the likelihood of injury, illness, and death related to extreme events such as storms, flooding, landslides, and wildfire.

Multnomah County, in partnership with the City of Portland, is preparing for climate change with a 2009 Action Plan, a 2013 Climate Change Preparation Plan, and recently released draft Climate Change Preparation Strategy reports (20-23). These documents focus on three main risks for the county: increased heat, poorer air quality, and changes to vector-borne diseases. The first two of these risks are likely to be impacted by strategies and investments under consideration in the CSCS Project.

The climate research and planning in Multnomah County and the greater Pacific Northwest suggests the Portland metropolitan region faces risks as a result of the urban heat island effect, which is most pronounced in areas dominated by impervious surfaces and minimal tree canopy. Even if global emissions are reduced, average temperatures are projected to increase by about 2.5-7.5 degrees Fahrenheit, raising concerns about heat-related illness and death. The Portland metropolitan region is also at risk from air quality issues arising from warmer temperatures and potential wildfire. Particulate matter and surface ozone have been shown to increase during summertime months as a function of temperature and air stagnation, and researchers project increases in ozone pollution in the Northwest. Health impacts such as respiratory illness are most pronounced near heavy traffic (24).

Actions by public health and other sectors can help protect people from some of the impacts of climate change. As threats increase, our ability to adapt to future changes may be limited; early action may provide the largest health benefits. Responding to climate change also provides opportunities to improve human health and well-being across many sectors, including energy, agriculture, and transportation (3). Metro's Climate Smart Scenario planning effort is a model of how planning to mitigate climate change can provide benefits across multiple sectors including transportation and health.

CURRENT HEALTH CONDITIONS, RISK FACTORS, AND COSTS

Approximately 11,050 people died in the three-county area (Clackamas, Multnomah and Washington counties) in 2010 (14). In Oregon, cancer, heart disease, lower respiratory conditions, stroke, unintentional injuries (including vehicle collisions), and diabetes are currently six of the top seven[1] leading causes of death (25).

Chronic health conditions decrease quality of life for many individuals. **Table 1** provides Oregon and Portland Metropolitan Statistical Area (MSA)[2] prevalence rates for chronic conditions and associated risk factors as estimated from the CDC's *Behavioral Risk Factor Surveillance System Survey* (BRFSS) in 2011(9). According to BRFSS, approximately 3% of adults in the region have survived a heart attack, a similar number suffer from chest pain or heart disease and 2.7% report having survived a stroke. These three cardiovascular conditions are highly associated with risk factors such as physical inactivity, high blood pressure, high cholesterol, and high body mass index (BMI). Recent BRFSS data also show that approximately 28% of adults report high blood pressure and 36% have had a high cholesterol reading in the past 5 years. Nearly 40% of adults report not meeting the recommended 150 minutes of physical activity per week. Over 35% are overweight and nearly 24% are obese (9).

Respiratory illness significantly degrades quality of life. Poor air quality contributes to conditions such as asthma and chronic obstructive pulmonary disease (COPD). A little more than 5% of adults report having COPD. Over 9% of Portland region adults report a current asthma condition; the Oregon adult rate is the sixth highest rate in the country (9, 26). At least 7–8% of children in Oregon have asthma, according to parental response, and when teens are directly surveyed, the prevalence estimate is 10% (26).

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[1] Alzheimer's disease is the sixth leading cause of death.

[2] The Portland-Vancouver-Hillsboro OR-WA MSA is defined as the seven county region including Clackamas, Columbia, Multnomah, Washington, and Yamhill Counties in Oregon, and Clark and Skamania Counties in Washington.

Table 1. Adult prevalence rates for chronic disease and associated risk factors (9)

BRFSS 2011 category	U.S. state median	Percent of adults [95% Confidence Interval]	
		Oregon	Portland MSA[3]
Heart attack	4.4	3.6 [3.1-4.2]	3.2 [2.5-4.0]
Chest pain or coronary heart disease	4.1	3.6 [3.1-4.0]	3.1 [2.4-3.7]
Stroke	2.9	2.9 [2.5-3.4]	2.7 [2.1-3.3]
Any physical activity last month?	73.8	80.3 [78.7-81.3]	81.5 [79.5-83.6]
150 minutes of aerobic per week	57.7	61.1 [59.3-62.9]	60.3 [57.8-62.8]
High blood pressure	30.8	29.9 [28.5-31.3]	27.9 [26.0-29.9]
Cholesterol checked and high in past 5 years	38.4	38.5 [36.8-40.2]	36.1 [33.8-38.5]
Overweight	35.7	34.8 [33.31-36.4]	35.8 [33.4-38.1]
Obese	27.8	26.7 [25.2-28.3]	23.7 [21.7-25.7]
Diabetic	9.5	9.3 [8.4-10.2]	8.5 [7.3-9.8]
Depression (ever treated)	17.5	23.9 [27.5-25.3]	22.8 [20.8-24.7]
COPD (Chronic obstructive pulmonary disease)	6.1	5.9 [5.2-6.7]	5.2 [4.2-6.3]
Ever had asthma	13.6	16.7 [15.4-18.0]	16.2 [14.3-18.0]
Current asthma	9.1	10.5 [9.4-11.5]	9.6 [8.2-11.0]

Chronic conditions are a significant financial burden to households and taxpayers. While costs are sometimes difficult to calculate due to inconsistent data collection systems and challenges related to co-morbidity, the CDC provides a Chronic Disease Cost Calculator to estimate state-specific Medicaid (Oregon Health Plan), Medicare, and private insurance expenditures for the treated population in any given year. The tool estimates annual direct medical costs in 2010 dollars and does not include lost wages, reduced productivity or years lost to premature death. It minimizes double counting across categories by statistically controlling for comorbidity (27, 28).

Table 2 displays the estimated expenditures for select transportation-related chronic diseases in Oregon, adjusting the costs for the proportion of population living in the three-county area[4]. More than $1.5 billion dollars is spent each year on cardiovascular disease in the region. Fifteen percent of Oregon's population are Medicaid recipients and 14%, including some that also qualify for Medicaid, are Medicare recipients (29). Of the $1.5 billion spent each year on

[3] Data at this level of geography is age-adjusted and can be compared to other MSAs and the State.

[4] The three-county area differs from the UGB.

cardiovascular disease, $623 million of that cost is borne by the taxpayer in Medicaid and Medicare payments and at least $481 million is paid by private insurance. The cost incurred in 2010 by all payers for maintenance and complications from diabetes is estimated at $710 million, asthma cost $176 million and depression, which is helped by physical activity, cost $382 million (27).[5]

Table 2. Estimates of 2010 three-county annual expenditures (in millions of 2010 dollars) for select chronic diseases

	Medicaid	Medicare	Private insurers	All payers[1]
Total cardiovascular disease[2]	$120	$503	$481	$1,551
Chronic heart failure	$12	$31	$10	$78
Coronary heart disease	$12	$167	$189	$470
Hypertension	$47	$149	$197	$592
Stroke	$48	$120	$63	$356
Other heart disease	$30	$106	$68	$258
Diabetes	$59	$199	$226	$710
Asthma	$34	$39	$66	$176
Depression	$22	$80	$157	$382

(1) All payers is estimated separately and may not equal the sum of Medicaid, Medicare, and private insurers.
(2) Total cardiovascular disease is a summation of the listed conditions, but only includes a portion of hypertension to avoid double counting. Similarly, diabetes complications can lead to cardiovascular disease; summing cardiovascular disease and diabetes would result in double counting. All other categories statistically control for listed conditions as well as common diseases not listed.

[5] The Chronic Disease Cost tool also provides projected costs; it estimates that expenditures for cardiovascular disease will increase by 79%, asthma by 66%, and diabetes by 77% by 2020 after accounting for inflation.

ITHIM DATA INPUTS

When compared to the three scenarios—A, B, and C—that were assessed in the prior CCC HIA, the Draft Approach reflects an investment strategy more ambitious than Scenario B but less ambitious than Scenario C.[6] The Draft Approach assumes implementation of investment priorities adopted in the 2014 Regional Transportation Plan (RTP) update. It also reflects a desire to go beyond the RTP financially constrained levels of investment for transit and lower-cost strategies such as TSMO and travel information programs.

The Integrated Transport and Health Impact Model (ITHIM) requires inputs that characterize the expected change in distance traveled by mode, air quality as measured by particulate matter (PM2.5), and the size of the population. **Table 3** compares inputs to the model across scenarios.

Table 3. ITHIM data inputs

Data Input	Baseline (2010)	Scenario A	**Scenario B** Adopted plans with increased revenue	**Scenario C** Scenario B plus additional policy/ infrastructure and new funding sources	**Draft Approach** Adopted 2014 RTP plus investment for transit and lower-cost TSMO and information	Data source and notes
Reduction in GHG		↓12%	↓24%	↓36%	↓29%	Modeled using ODOT's GreenSTEP. GreenSTEP inputs include Metro's Household Activity Survey, monitored PM2.5 emissions rates from DEQ.
Miles traveled per person per week	134	125	117	102	112	
Average distance by mode per person per week[1]	Walk=1.3 Bike=2.1 Car=129.9	Walk=1.7 Bike=2.2 Car=120.8	Walk=1.8 Bike=3.0 Car=111.5	Walk=1.8 Bike=3.6 Car=96.3	Walk=1.8 Bike=3.4 Car=106.8	
Distance by mode[1] as a percentage of total miles traveled	Walk=1.0% Bike=1.6% Car=97.2%	Walk=1.3% Bike=1.7% Car=96.7%	Walk=1.5% Bike=2.6% Car=95.6%	Walk=1.8% Bike=3.5% Car=94.2%	Walk=1.6% Bike=3.0% Car=95.0%	
$PM_{2.5}$ (µg/m3)[2]	7.7291	6.4429	6.4180	6.3925	6.4109	
		↓16.6%	↓17.0%	↓17.3%	↓17.1%	
UGB population	1,481,118	1,954,716 (↑32%, 2035 Estimate)				U.S. Census

(1) ITHIM use miles traveled per person per week for the modes listed.
(2) The CCC HIA used the GreenSTEP modeled value of 6.6317 (µg/m3) as the $PM_{2.5}$ baseline. For this HIA, OHA-PHD used a 5-year (2008-2012) average of monitored data as the baseline; the scenarios reflect modeled $PM_{2.5}$ from GreenSTEP.

[6] See the CCC HIA for a more detailed description and discussion of these scenarios.

The Draft Approach assumes that 112 miles will be traveled per person per week and that a slightly lower percentage of those miles will be traveled by car than in Scenario B (95.0% vs. 95.6%). The distance walked and biked is an important factor in the ITHIM model due to the high burden of disease associated with physical inactivity. The Draft Approach's average distance walked per person per week is 1.8 miles, approximately equal to both Scenario B & C. Distance traveled by bicycle (3.4 miles) in the Draft Approach is much closer to Scenario C (3.6 miles) than Scenario B (3.0 miles).

Traffic safety is also impacted by the miles traveled by mode, with the miles traveled by car (VMT) the most influential; the Draft Approach is more aggressive than Scenario B in reducing VMT.

Finally, the air pollution pathway of ITHIM is calculated by percent reduction in $PM_{2.5}$. In the previous HIAs, OHA-PHD used outputs from ODOT's GreenSTEP model for both baseline and scenarios. With the release of the 2012 monitored $PM_{2.5}$ it became apparent that the GreenSTEP model may not be the most accurate reflection of baseline $PM_{2.5}$. Therefore, in this HIA, OHA-PHD chose to use a 5-year average (2008-2012) of monitored $PM_{2.5}$ data as baseline. This change to $PM_{2.5}$ baseline was significant enough to warrant releasing updated ITHIM results contained within the CCC HIA for Scenarios A, B, and C; this allows for a more accurate comparison of the Draft Approach to previously studied options and ongoing design choices under consideration as Metro works with local, regional and state partners to finalize a recommended strategy that meets the GHG reduction target.

FINDINGS: Overview

ITHIM was identified during the development of the CSCS HIA in 2012 as a way to quantify morbidity (illness and severe injuries) and mortality (death) from transportation in three health pathways: physical activity, air quality as measured by $PM_{2.5}$, and traffic safety. Morbidity is measured by disability-adjusted life years (DALYS) which is a summation of years of life lost (YLL) from a disease and a measure of years lived with a disability (YLD). **Table 4** provides detailed ITHIM results[7] by exposure pathway for the Draft Approach scenario with Scenarios A, B, and C as a reference. Expected health benefits are graphically presented in **Figure 3** on the next page where the size of the pie chart varies according to the relative size of overall health benefits by scenario and slices of the pie represent the health benefits attributable to each pathway.

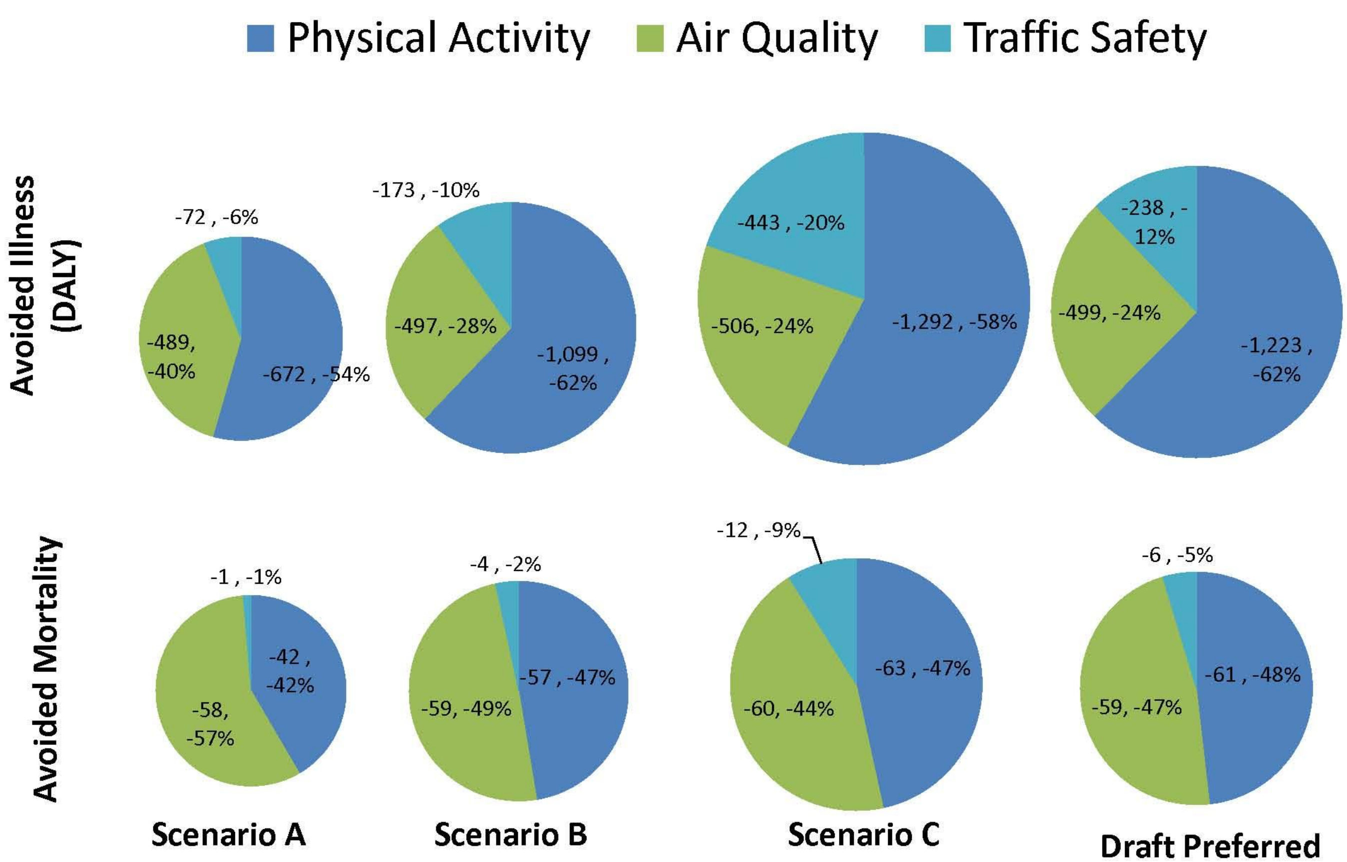
Table 4. Overview of ITHIM results (avoided morbidity and mortality) by scenario and attributable pathway

Attributable Pathway	Scenario A	Scenario B	Scenario C	Draft Approach
Change in Morbidity – Count as measured by DALYs (% change from baseline)				
Physical Activity	-672 (0.7%)	-1,099 (1.2%)	-1,292 (1.4%)	-1,223 (1.3%)
Air Quality	-489 (2.4%)	-497 (2.5%)	-506 (2.5%)	-499 (2.5%)
Traffic Safety	-72 (2.0%)	-173 (4.9%)	-443 (12.5%)	-238 (6.7%)
Total	**-1,233 (-1.0%)**	**-1,769 (-1.5%)**	**-2,240 (-1.8%)**	**-1,960 (-1.6%)**
Change in Mortality – Count (% change from baseline)				
Physical Activity	-42 (1.0%)	-57 (1.4%)	-63 (1.6%)	-61 (1.5%)
Air Quality	-58 (1.8%)	-59 (1.8%)	-60 (1.8%)	-59 (1.8%)
Traffic Safety	-1 (1.2%)	-4 (3.5%)	-12 (10.5%)	-6 (5.1%)
Total	**-101 (-1.5%)**	**-120 (-1.8%)**	**-135 (-2.0%)**	**-126 (-1.8%)**

The model suggests that the total amount of prevented premature deaths from all pathways for the Draft Approach will be 126 in the year 2035 after adjusting for population growth. Forty-eight percent, or 61 of those prevented premature deaths, will be avoided due to an increase in physical activity levels. Forty-seven percent, or 59 deaths, are attributable to cleaner air as measured by decreased ambient $PM_{2.5}$ levels; and five percent of avoided deaths, or six fatalities, are attributable to safer road conditions. Morbidity in the Draft Approach should decrease by 1,960 disability adjusted life years (DALYs). Conceptually, morbidity is easier to think about as a percent change from baseline rates of illness and disease studied; in the Draft Approach disease rates would decrease by 1.6%.

[7] Results are presented in counts (or cases) avoided as well as percent reduction from current disease prevalence levels. All results in the report have been adjusted approximately 32% upward to account for population growth within the UGB.

Figure 3. Annual (in 2035) health benefits attributable to pathway (physical activity, air quality, and traffic safety) by scenario



FINDINGS: Physical Activity

Physical activity is an important factor in preventing chronic disease and death. Physical inactivity is the fifth largest contributor to current disease burden in the U.S.(30). Reductions in GHG emissions through investments that prompt increases in walking and bicycling to transit and community destinations are likely to produce substantial health benefits (31).

Table 5. ITHIM results (avoided mortality and morbidity) by scenario for physical activity

	Baseline (2010)	Scenario A	Scenario B	Scenario C	Draft Approach
Average distance by mode per person per week[1]	**Walk=1.3** **Bike=2.1** Car=129.9	Walk=1.7 Bike=2.2 Car=120.8	Walk=1.8 Bike=3.0 Car=111.5	Walk=1.8 Bike=3.6 Car=96.3	**Walk=1.8** **Bike=3.4** Car=106.8
Avoided Deaths		-42 (1.0%)	-57 (1.4%)	-63 (1.6%)	-61 (1.5%)
Decrease in Illness (DALYs)		-672 (0.7%)	-1,099 (1.2%)	-1,292 (1.4%)	-1,223 (1.3%)

The transportation and land use investments and strategies will result in modest increases in walking and biking that translate into impressive gains in health across the region. ITHIM results in **Table 5** suggest that, on average, each person will take one additional half-mile walk each week in the Draft Approach. Such a modest increase in walking equates to approximately 48 avoided premature deaths annually by 2035. Similarly, ITHIM suggests 13 premature deaths would be avoided each year by 2035 if every person would ride a bike an additional 1.3 miles (26 blocks in the City of Portland) each week. Together, small increases in walking and cycling associated with the Draft Approach could help prevent as many as 61 deaths (**Figure 4**). Illness and disease influenced by physical activity are expected to decrease by 1.3% or 1,223 DALYs each year.

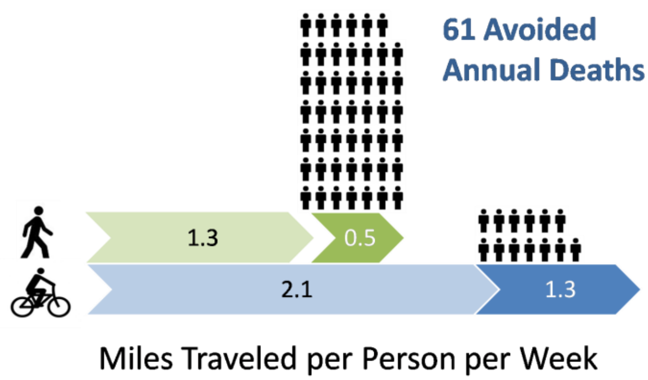


Figure 4. Physical activity health benefits for Draft Approach

Transportation choices allow individuals to routinely and flexibly integrate physical activity into everyday lives. Adults and children are more likely to choose active forms of transportation when they perceive they will be able to do so safely (32, 33). The most effective way to increase safety for active modes is through traffic calming measures and greater physical separation from motorized traffic (34-37). Design details and investments make streets more complete, connected and comfortable for potential pedestrians and cyclists. While design is not accounted for within ITHIM, it may contribute to increased walking and bicycling and reductions in traffic hazards.

FINDINGS: Air Quality

Improving overall air quality is an important health benefit of GHG reduction. Reducing per capita VMT and implementing clean fuel technologies are expected to decrease air pollutants attributable to light-duty vehicles. These pollutants include: $PM_{2.5}$, ozone precursors and air toxics such as benzene, 1,3-butadiene, arsenic, and chromium VI (38, 39). Reductions of these pollutants will likely result in increased respiratory health, decreased cardiovascular disease and events such as heart attacks, and decreased cases of cancers such as lung cancer and leukemia (38-44).

ITHIM developers chose $PM_{2.5}$ as the only indicator for mobile, onroad sources[8] (40, 45). **Table 6** provides ITHIM inputs and results. Inputs for ITHIM air quality analysis use 5-year monitored averages and modeled ambient concentrations from ODOT's GreenSTEP for scenarios. ITHIM suggests that the 17.1% reduction in ambient concentrations of $PM_{2.5}$ under the Draft Approach would result in at least 29 annual avoided deaths from respiratory conditions, heart disease, and lung-cancer cases. ITHIM predicts an additional 30 avoided premature deaths from diseases often attributable to physical activity but also caused by $PM_{2.5}$ – stroke, ischemic heart disease, and hypertensive heart disease. Improved air quality would also reduce respiratory illness and inflammatory heart disease by at least 2.5%.

Light-duty Vehicle (LDV) Pollutants

Particulate Matter: While heavy diesel vehicles are a larger contributor of $PM_{2.5}$, LDVs also contribute particulate matter. Health considerations include respiratory and cardiovascular disease and death.

Ozone Precursors: NO_x and SO_x are both associated with LDV emissions. Ozone can exacerbate respiratory illnesses such as COPD and asthma.

Benzene: Gasoline-powered LDVs are the largest source of ambient, outdoor benzene and its harmful effects include anemia and leukemia.

1,3-Butadiene: LDV exhaust is a major contributor of 1,3-butadiene. Inhalation results in irritation of the eyes, nasal passages, throat, and lungs. It may cause cardiovascular diseases and is associated with increased risk of leukemia.

For more information, please see the Portland Air Toxics Solutions Project

www.deq.stat.or.us/aq/toxics/pats.htm

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[8] While OHA-PHD accepted this choice of pollutant based on the scientific consensus about the strength and causal nature of the relationships between $PM_{2.5}$ and health (40, 45), relying on $PM_{2.5}$ as the only indicator underestimates many of the health benefits associated with reductions in air toxics and other pollutants in emissions of light-duty gasoline vehicles. For a more detailed discussion, please see the "FINDINGS: Cleaner Air" and "Appendix F. Air Quality White Paper" in the Community Climate Choices HIA (7).

Table 6. ITHIM results (avoided mortality and morbidity) by scenario for air quality ($PM_{2.5}$)

	Baseline (2010)	Scenario A	Scenario B	Scenario C	Draft Approach
$PM_{2.5}$ (µg/m3)[2]	7.7291	6.4429 ↓16.6%	6.4180 ↓17.0%	6.3925 ↓17.3%	6.4109 ↓17.1%
Avoided Deaths		-58 (1.8%)	-59 (1.8%)	-60 (1.8%)	-59 (1.8%)
Decrease in Illness (DALYs)		-489 (2.4%)	-497 (2.5%)	-506 (2.5%)	-499 (2.5%)

Some populations are at greater risk for health problems stemming from exposure to air pollution: those with pre-existing respiratory and cardiovascular conditions, low-income individuals, youth, elderly and those living near busy roads and other pollution sources. For example, people with lung cancer are at increased risk of death when exposed to moderate levels of $PM_{2.5}$ (46). Low-income housing is disproportionately sited adjacent to busy roads (47), more likely to be near point-source industry and often has greater indoor air risks such as mold. The cumulative burden for such vulnerable communities is higher than the region and modest improvements in air quality would have a significant impact (48).

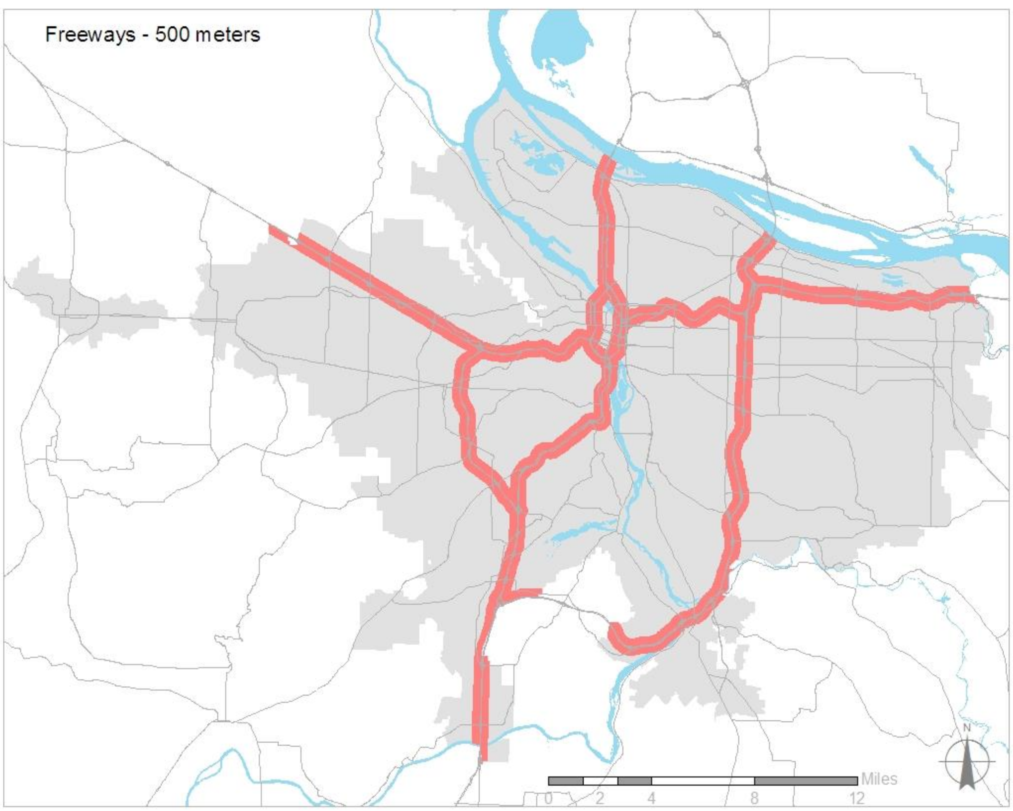


Figure 5. Area within 500 meters of freeways

Near-road Exposure

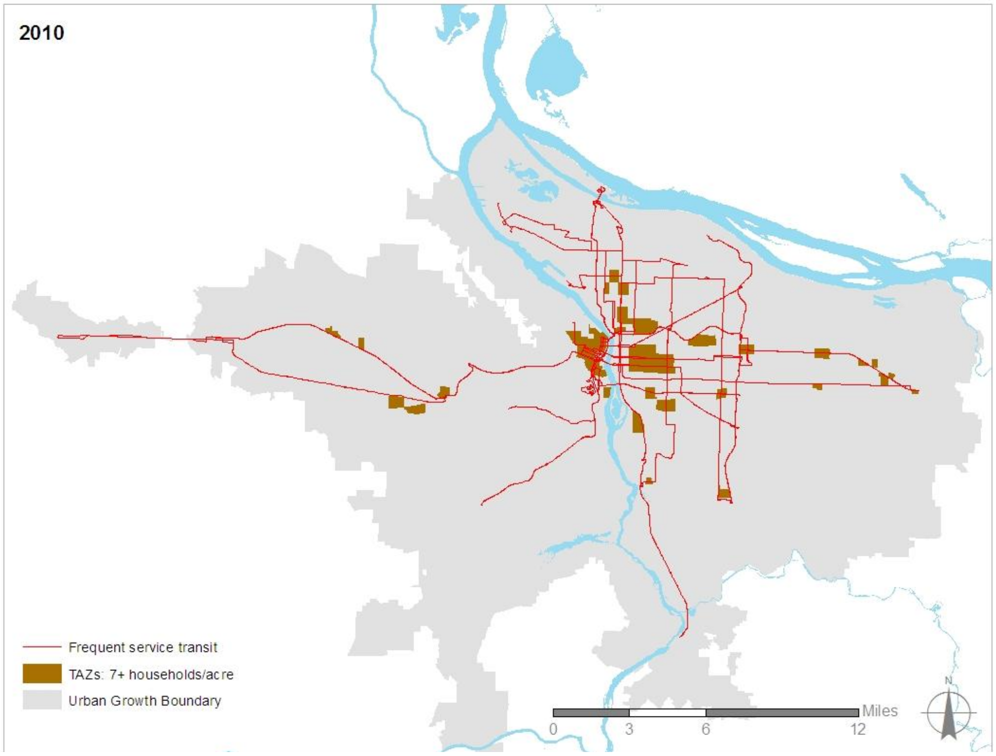
Some air pollution is highly localized, and communities along transportation corridors such as highways and major arterials are at highest risk for transportation-related pollution (49, 50). Modest reductions in vehicular emissions for light-duty vehicles – particularly PAH, ozone, particulate matter such as $PM_{2.5}$, benzene and 1,3 butadiene – could lead to significant health improvements for people living, working, and playing along transportation facilities. The CDC states there is a causal association between near-road exposure and asthma exacerbation and suggestive evidence of onset of childhood asthma, non-asthma respiratory illness, impaired lung function, cardiovascular illness and death, and all-cause mortality (51-53).

To understand the extent of this potential health benefit, OHA-PHD analyzed Metro data for the proportion of households living near freeways and arterials (**Figure 5**). The map highlights areas within the region that are at least 500 meters from a freeway in pink; 12.6% of those living within the UGB in 2010 lived in the pink area. A similar analysis showed 40.9% of the population in 2010 lived within 300 meters of a major arterial or freeway[9].

Metro assumes that a large proportion of population growth will occur along the region's transportation corridors, all of which feature frequent transit service. For example, in 2010 295,000 households lived in traffic analyses zones (TAZ) within 300 meters of frequent service transit lines; by 2035, this is expected to increase to 443,000 households. Visually, this can be seen by mapping TAZs within 300 meters of frequent service transit lines with housing density of greater than 7 households per acre (**Figure 6**).

Public health recognizes that increased density along transit corridors facilitates health through increased physical activity, access to health promoting resources and climate benefits. Many of these benefits are discussed in detail in other sections of the HIA. However those who live, work and exercise along the corridors are at increased risk of exposure to transportation-related air pollutants. Design of buildings and transportation facilities including site orientation (building doors and windows, bus shelters), placement of active transportation facilities that increase physical separation, inclusion of trees and other large vegetation in buffer zones and indoor air filtration on new and redeveloped buildings are examples of mitigation strategies that may help address this near-road exposure risk.

[9] Freeways and major arterials were classified by Metro data (RLIS). Examples of freeways are Interstate 5 and Highway 217. Examples of major arterials are SE 82nd Avenue and W Burnside Street.



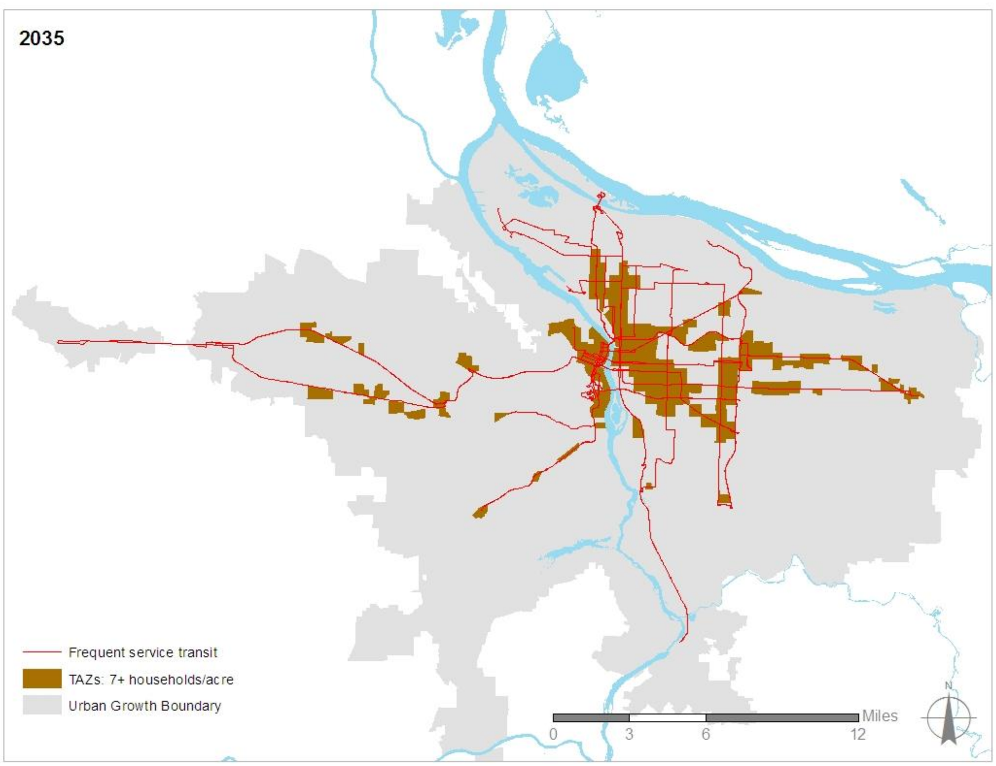


Figure 6. Density of households (7 per acre or greater) along high frequency transit lines in 2010 (above) and 2035 (below)

FINDINGS: Traffic Safety

The transportation and land use investments and strategies included in Metro's Draft Approach reduce reliance on single-occupancy travel and assume shorter overall trips. An individual traveling fewer miles, particularly by car, lowers their risk of exposure for collisions. Consequently, ITHIM estimates that the Draft Approach Scenario will result in six fewer traffic fatalities and a 6.7% reduction in severe injuries (**Table 7**).

Table 7. Avoided traffic fatalities and severe injuries (measured in DALYs) by exposure pathway and scenario

Avoided	Scenario A		Scenario B		Scenario C		Draft Approach	
	Pop Adj. Count[1]	Percent Decrease	Pop Adj. Count[1]	Percent Decrease	Pop Adj Count[1]	Percent Decrease	Pop Adj. Count[1]	Percent Decrease
Fatality	-1	1.2%	-4	3.5%	-12	10.5%	-6	-5.1%
YLL	-28	1.2%	-84	3.5%	-251	10.5%	-122	-5.1%
YLD	-44	3.8%	-89	7.6%	-192	16.4%	-116	-9.9%
DALY	-72	2.0%	-173	4.9%	-443	12.5%	-238	-6.7%

(1) ITHIM estimates disease reduction based on stable (2010) population figures. Assuming disease burden rates remain the same in 2035, counts are adjusted upward by addressing the 32.0% increase in population expected within the Urban Growth Boundary from 2010 to 2035.

To understand how changing miles traveled by mode impacts safety, ITHIM distributes and analyzes the probability of a collision and accompanying fatality or major injury along minor, major, and highway roads. **Table 8** provides estimates of incidences of serious injury by travel mode; **Table 9** on the following page provides estimates of fatalities by mode.

Table 8. ITHIM estimates of expected DALYs[2] from severe traffic injuries by mode in 2035

Mode	Baseline	Scenario A	Scenario B	Scenario C	Draft Approach
Walk	889.2	958.3	952.8	898.1	938.5
Cycle	316.7	312.3	356.7	372.7	377.8
Bus	0.0	0.0	0.0	0.0	0.0
Car	1905.8	1773.9	1639.5	1418.1	1571.1
Motorbike	424.5	419.4	413.9	404.4	411.1
Total [1]	3555.4	3483.0	3382.0	3112.5	3317.6
Sum of difference between baseline and scenario		-72.4	-173.3	-442.9	-237.8

(1) Note that the total is not the sum of the modes presented as it also adds in a small but fixed number of heavy goods vehicle crashes.

(2) ITHIM estimates disease reduction based on stable (2010) population figures. Assuming disease burden rates remain the same in 2035, counts are adjusted upward by addressing the 32.0% increase in population expected within the Urban Growth Boundary from 2010 to 2035

Table 9. ITHIM estimates of expected traffic fatalities[2] by mode in 2035

Mode	Baseline	Scenario A	Scenario B	Scenario C	Draft Approach
Walk	34.3	37.0	36.7	34.6	36.1
Cycle	10.4	10.2	11.7	12.4	12.5
Bus	0.0	0.0	0.0	0.0	0.0
Car	53.4	49.7	45.9	39.7	44.0
Motorbike	15.9	15.8	15.6	15.3	15.5
Total [1]	114.8	113.4	110.7	102.7	108.9
Sum of Difference between Baseline and Scenario		-1.4	-4.0	-12.1	-5.9

(1) Note that the total is not the sum of the modes presented as it also adds in a small but fixed number of heavy goods vehicle crashes.

(2) ITHIM estimates disease reduction based on stable (2010) population figures. Assuming disease burden rates remain the same in 2035, counts are adjusted upward by addressing the 32.0% increase in population expected within the Urban Growth Boundary from 2010 to 2035

A closer look at Tables 8 and 9 confirm gains in traffic safety for cars, but an increase in the absolute number of bicyclist and pedestrian severe injuries and fatalities. (See figure 6 below). Even though overall traffic safety will improve, and the risk to each biker and walker will decrease, the increase of bicyclists and pedestrians on minor streets and arterials results in an increase in the absolute number of accidents and resulting fatalities and severe injuries for these two modes. The model suggests the Draft Approach will result in 9.3 fewer vehicular deaths annually even as pedestrian and cyclists deaths increase by two each. Expressed as rates, all modes would be safer.

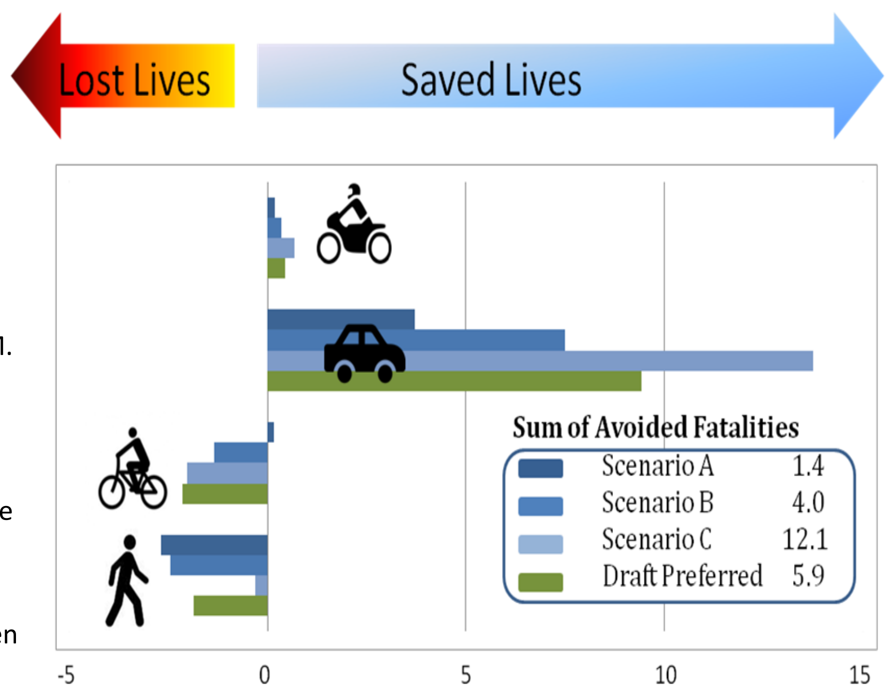


Figure 7. Traffic fatalities by mode

This underscores the need to design for safety for non-motorized users – a factor not fully accounted for in ITHIM. Special attention to design considerations, such as “complete streets,” will encourage walking and bicycling and help mitigate the increased safety burden on cyclists and pedestrians (54).

Similarly, ITHIM folds walking to and from transit into the pedestrian category. Aggressive projections in transit miles traveled for the Draft Approach also suggests design around transit/bus stops should be a high priority to both encourage walking and biking to transit and protect pedestrians and bicyclists traveling to and from transit.

FINDINGS: Monetizing Health Benefits

Health impact assessment seeks to understand health-related tradeoffs in policy making, and decision-makers find monetized information helpful in making policy. Cost-of-illness (COI) modeling, is routinely used by health economists to understand cost-effectiveness and to forecast national costs of a disease given prevalence and treatment trends (19, 56). COI's general approach is to estimate the financial burden associated with an illness through identifying direct (payments to doctors, hospitals and pharmacies) and indirect (lost income and productivity) costs. Because it does not address some elements of illness such as pain and suffering, COI underestimates the true cost of illness, particularly when illness outcomes are severe. For this reason, COI estimates should be considered a lower-bound estimate of willingness to pay (WTP), or what economists have determined society would be willing to pay to avoid an outcome such as illness or death (57).

COI is utilized in EPA and CDC policy work (19). It is also used by national disease associations (American Heart Associate, American Diabetes Association, etc.) to track specific diseases or disease clusters and state environmental organizations to understand the cost of pollution (58). Most national COI analyses leverage nationally representative surveys of medical utilization such as the Medical Expenditure Panel Survey to aggregate costs across the medical system as well as national economic surveys to estimate lost wages for indirect costs. Most COI models statistically control for co-morbid conditions (i.e., if more than one condition is present, the models isolate the cost of each independently).

To apply COI information, OHA-PHD performed a literature search for national costs by disease, prioritizing national governmental guidance or peer-reviewed estimates from national medical associations. **Table 10** on the next page provides estimates of national COI by disease, adjusted to 2010 dollars and scaled by the proportion of the U.S. population living within the urban growth boundary in 2010 (0.48%). With the exception of breast, colon and lung cancer, all COIs include both direct (medical) and indirect (lost earnings and productivity) costs where indirects account for approximately 20 to 35 percent of the COI. Note that a range is provided for stroke and heart disease. The higher estimates represent fine-tuning of the basic estimates provided by the American Heart Association (60-63). A range is also provided for dementia due to the two different methodologies for accounting for informal caregiving (65).

ITHIM estimates health impacts by defining counts and percentage change from baseline. The percentage change can also be thought of as the fraction of the disease attributable to the environmental or policy change. The attributable fraction is applied to appropriately scaled national or state COI to estimate the monetary benefit of decreased illness.

Table 10. National cost-of-Illness (COI), scaled to Portland Metropolitan Region

Condition[1]	National COI (Base Year) in millions	National COI in millions, 2010$	Regional Share in millions, 2010$	Source
Cancer				
Breast cancer[2]	$27,378 (2010)	$27,378	$131	National Cancer Institute - Mariotto et al (2011) (59)
Colon and rectum cancer[1]	$26,942 (2010)	$26,942	$129	
Lung cancer[1]	$51,073 (2010)	$51,073	$245	
Cardiovascular				
Stroke	$36,500 (2010)	$36,500	$175	American Heart Association - Go et al (2013) (60)
Stroke	$105,200 (2010)	$105,200	$505	American Heart Association & American Stroke Association - Ovbiagele et al (2013) (61)
Heart Disease	$250,800 (2010)	$250,800	$1,203	American Heart Association - Go et al (2013) (60)
Heart Disease	$336,800 (2008)	$340,168	$1,632	Heidenreich et al (2011) (62) adjusted for heart failure from Voigt et al (2014) (63)
Respiratory				
Asthma/COPD	$68,000 (2008)	$68,680	$329	National Heart Lung and Blood Institute (64)
Mental Illness				
Dementia	$157,000-$215,000 (2010)	$157,000-$215,000	$753-$1,031	Hurd, (2013) (65)
Depression	$83,100 (2000)	$105,230	$505	Greenberg et al (2003) (66)
Other				
Diabetes	$245,000 (2012)	$232,750	$1,117	American Diabetes Association (2013) (67)
Traffic Injuries	$41,789 (2005)	$46,657	$224	CDC's Motor Vehicle Injury Prevention – Naumann et al (2010) (68)

(1) Includes new cases and complications
(2) Cancer costs are direct medical costs only. All other conditions include both direct and indirect (lost wages and productivity).

Table 11 (page 32) displays the annual expected morbidity savings by disease and scenario for the Portland Metropolitan region, based on each disease's attributable fraction of the regional COI. According to this analysis, between $4.8 and $5.8 billion (in 2010$) is annually spent in the Portland metropolitan region on the listed diseases. The Draft Approach is expected to reduce spending on diseases listed by approximately 2.1%. This reduction equates to an annual savings in the region of $100-$125 million, including nearly $64 million a year in cardiovascular savings,

$35 million in savings associated with severe traffic injuries, $26 million in diabetes savings, $11 million in treating mental health, $5.5 million in cancer savings, and $1.3 million in asthma savings. With the exception of the cancers, all of these savings include both direct (medical) and indirect (earnings, lost productivity) costs.

OHA-PHD also used a second method to estimate cost savings associated with a subset of the diseases discussed above. The CDC provides an alternative source of data for COI with its Chronic Disease Cost Calculator(27). OHA-PHD undertook additional analysis of morbidity cost savings because the calculator (1) provides state-specific COI estimates and (2) differentiates between expenditures paid by private versus public (Medicare and Medicaid/Oregon Health Plan) insurers. **Table 12** provides results from the Chronic Disease Cost Calculator, which are similar to estimates from the National COI estimates in Table 12. However, estimates from the Chronic Disease Cost Calculator provide insight on the distribution of payment for healthcare costs. The Draft Approach is estimated to result in $35 million annual savings from improved cardiovascular health (stroke excluded) with 38% of the reduction coming from public insurer costs. It is also expected to result in $9 million in savings from stroke with 47% of the savings going to public programs, and 36% of the $16 million in diabetes savings in public insurer costs. In total, public funds are estimated to see savings of $23 million annually.

In policy cost-benefit analysis, mortality is monetized by estimating the change in the number of premature deaths attributable to the policy and then multiplying by the value of statistical life (VSL). Although the name 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 mortality risk (55). However, VSL does not represent actual costs borne by any particular party.

The VSL literature is large and robust with guidance from federal agencies on how to apply VSL to planning activities. The U.S. EPA's current default VSL is $7.9 million (in 2008$) and is based on 26 published VSL estimates (55). U.S. DOT's default VSL is $9.1 million (in 2012$) with a range of $5.2 to $12.9 million provided for sensitivity analyses (18). Using the U.S. DOT VSL guidance, 126 avoided premature deaths by 2035 should be valued at $1.09 billion annually with a range of $622 million to $1.54 billion (2010$).

Table 11. Annual expected morbidity savings by disease and scenario for the Portland Metropolitan UGB region (in 2035, in millions, 2010$)

Disease	Regional COI	Scenario A		Scenario B		Scenario C		Draft Approach	
		Attributable Fraction	Regional Attributable Costs	Attributable Fraction	Regional Attributable Costs	Attributable Fraction	Regional Attributable Costs	Attributable Fraction	Regional Attributable Costs
Cancer									
Breast[1]	$131	0.22%	$0.29	0.35%	$0.46	0.43%	$0.56	0.40%	$0.53
Colon and rectum[1]	$129	0.39%	$0.50	0.61%	$0.79	0.75%	$0.97	0.70%	$0.90
Lung[1]	$245	1.60%	$3.92	1.64%	$4.02	1.67%	$4.09	1.65%	$4.04
Cardiovascular (CVD)									
Stroke	$175-$505	1.76%	$3.08-$8.88	2.50%	$4.38-$12.62	2.82%	$4.94-$14.23	2.70%	$4.73-$13.63
Heart Disease	$1,203-$1,632	2.21%	$26.59-$36.06	2.94%	$35.37-$47.98	3.26%	$39.22-$53.20	3.14%	$37.78-$51.24
Respiratory									
Asthma/COPD	$329	0.44%	$1.45	0.45%	$1.48	0.46%	$1.52	0.45%	$1.48
Mental Illness									
Dementia	$753-$1,031	0.63%	$4.74-$6.50	0.84%	$6.33-$8.66	0.96%	$7.23-$9.90	0.91%	$6.85-$9.39
Depression	$505	0.28%	$1.41	0.51%	$2.57	0.70%	$3.53	0.65%	$3.28
Other									
Diabetes	$1,117	1.07%	$11.95	2.09%	$23.34	2.46%	$27.47	2.33%	$26.02
Traffic Injuries	$224	2.03%	$4.54	4.87%	$10.90	12.46%	$27.89	6.69%	$14.97
Total Annual Health Savings From Reduced Illness	**$4,812 - $5,848**		**$58.5-$75.5**		**$89.6-$112.8**		**$117.4-$143.4**		**$100.6-$125.5**

(1) Cancer costs are direct medical costs only. All other conditions include both direct and indirect (lost wages and productivity).

Table 12. Annual expected morbidity savings for Draft Approach by disease for the Portland Metropolitan region (in 2035, in millions, 2010$) according to the CDC's Chronic Disease Cost Calculator v2.0

Condition (ITHIM's Attributable Fraction from Draft Approach)	All Payers Expenditures		Medicaid Expenditures		Medicare Expenditures		Private Insurers Expenditures		Absenteeism		All Payers+ Absenteeism	
	Regional (UGB)	Draft Approach	Regional (UGB)	Draft Approach	Regional (UGB)	Draft Approach	Regional (UGB)	Draft Approach	Regional (UGB)	Draft Approach	Regional (UGB)	Draft Approach
Asthma (0.45%)	$158.90	$0.72	$30.54	$0.14	$35.57	$0.16	$59.15	$0.27	$15.46	$0.07	$174.36	$0.78
Depression (0.65%)	$344.85	$2.24	$19.72	$0.13	$72.30	$0.47	$141.88	$0.92	$36.34	$0.24	$381.19	$2.48
Diabetes (2.33%)	$640.99	$14.94	$52.97	$1.23	$179.39	$4.18	$204.13	$4.76	$23.97	$0.56	$665.35	$15.50
Stroke (2.70%)	$321.66	$8.68	$43.30	$1.17	$108.64	$2.93	$56.83	$1.53	$20.49	$0.55	$342.15	$9.24
Heart Disease (CVD without Stroke) (3.14%)	$1,077.86	$33.84	$65.34	$2.05	$345.24	$10.84	$377.33	$11.85	$42.14	$1.32	$1,120.00	$35.17

CONCLUSIONS AND RECOMMENDATIONS

The policies and investments under consideration have the potential to significantly impact public health throughout the Portland metropolitan region by reducing greenhouse gases, increasing physical activity, improving air quality, and improving traffic safety.

The changing climate has the potential to significantly impact health in the region.

- Demonstrate regional leadership and mitigate climate change by adopting and implementing a CSCS Scenario that meets or exceeds the GHG target set for the Portland metropolitan area by the Land Conservation and Development Commissions (LCDC).

Physical inactivity contributes to leading causes of death; diseases linked to physical inactivity cost the Portland metropolitan region at least $1.5 billion annually in both direct costs, such as doctor visits, medication and hospitalization, and indirect costs, such as lost productivity.

- Support active transportation through the implementation of Complete Streets strategies and the completion of the active transportation network throughout the region.
- Access to, and bicycle and pedestrian-friendly designs of, transit and bus stops should be a high priority to both encourage increased walking and bicycling and to protect bicyclists and pedestrians traveling to and from transit.
- Integrate multi-modal designs in road improvement and maintenance projects to support all users.
- In future Regional Transportation Plan updates, monitor increasing physical activity using a measure of travel distance or travel time by active mode rather than mode share or number of trips to emphasize the health benefits.
- Reach or exceed the 1.8 miles walked by pedestrians and 3.4 miles bicycled each week by 2035 as projected in the Draft Approach.

Coupled with important infrastructure improvements outlined above, reducing VMT levels throughout the region will increase safety for all populations.

- Adopt and implement land use and transportation investments and strategies that reduce per capita VMT, such as from 130 to under 107 miles per week by 2035.
- Prioritize transportation investments throughout the region that will help reduce VMT including (1) expanding transit and (2) providing travel information and incentives to encourage car sharing, use of transit, and active transportation options.

Transportation-related air pollutants such as $PM_{2.5}$ are harmful to public health. 40% of the region's population lives near freeways and large roads, leaving them at increased risk for health effects associated with near-roadway air pollution.

- Using strategies that couple technology improvements with reductions in light-duty VMT and increases in active transportation, reduce regional ambient concentrations of $PM_{2.5}$ to 6.41 ug/m3 or below as projected in the Draft Approach by 2035.
- Support state efforts to transition to cleaner, low carbon fuels and more fuel-efficient vehicles and technologies, including Oregon's Clean Fuels Program and Zero Emissions Vehicle Program.
- Protect populations living, working and attending school near highways and major roads with siting, design and/or mechanical systems that reduce indoor air pollution. This is especially critical for facilities housing and/or providing services to vulnerable populations such as children, older adults and low-income populations.
- Further reduce localized air pollution along major roads and freeways by continuing to transition to non-diesel or clean diesel fuels when expanding transit fleet in the region.
- Convene a regional work group to further address episodic air quality events. Solutions should be season-specific and could promote incentives for short-term, alternative commute arrangements.
- Continue to prioritize transportation investments throughout the region that will help reduce air pollution and air toxics, including expanding transit service, using technology to manage the transportations system, building "complete streets" and providing travel information and incentives to encourage car-sharing, carpooling and use of transit and active transportation options when possible.

Not all residents of the Portland metropolitan region have equal access to healthy transportation options and health-promoting community resources.

- To improve health equity, OHA-PHD recommends Metro ensure social and health goals are considered when prioritizing investments by explicitly and transparently addressing how investments link low-income and other vulnerable households to health-promoting resources.

Maximize possible health benefits by monitoring key health indicators, expanding partnerships that promote health, and developing tools to support the consideration of health impacts in future land use and transportation decisions throughout the region.

- OAR 660-044 directs Metro to identify performance measures and targets to monitor and guide implementation of the preferred approach, including performance measures already adopted by Metro to meet requirements of OAR 660-012-0035(5). Several of the measures laid out in the Metro document Performance Monitoring and Reporting will help monitor key health determinants throughout the region such as: changes in VMT, changes in bike and pedestrian fatalities and severe injuries, and changes in motor vehicle fatalities and severe injury rates. This HIA recommends clear benchmarks and regular monitoring of each of these indicators to ensure health-promoting improvements throughout the region. The document also lists bicycle and pedestrian mode share: while this HIA is supportive of improvements in mode share, the largest public health benefits comes from increases in active transportation distance and/or time. This report recommends an additional measure to track distance and/or time traveled to enable monitoring of changes in activity levels, not just percentage of total trips.

- The healthy implementation of the final scenario throughout the region will require new resources and partnerships to understand how recommended strategies and investments impact health at the local and regional levels. OHA-PHD recommends that Metro and ODOT continue to work with other State and regional partners, such as the Health and Transportation Subcommittee of the Oregon Modeling Steering Committee, to develop tools to support assessments that measure the impact future plans have on air quality, safety, active transportation and climate change.

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APPENDIX A: CSS HIA Advisory Committee members

Tom Armstrong, City of Portland
Sarah Armitage, DEQ
Adam Barber, Multnomah County Planning
Aida Biberic, DEQ
Margi Bradway, ODOT
Aaron Breakstone, Metro
Ben Bryant, City of Tualatin
Karen Buehrig, Clackamas County
Steve Butler, City of Milwaukie
Betsy Clapp, Multnomah County Health Dept.
Lynda David, Regional Transportation Council
Erica Dejong, Office of Equity and Inclusion
Jennifer Donnelly, Dept. of Land Conservation & Development
Kim Ellis, Metro, Principal Transportation Planner
Leah Fisher, Health Promotion & Chronic Disease Prevention
Barbara Fryer, City of Beaverton
Jana Gastellum, Oregon Environmental council
Heather Gramp, PHD
Mara Gross, Coalition for Livable Future
Renee Hackenmiller-Paradis, OHA
Tia Henderson, Upstream Public Health
Eric Hesse, TriMet
Jon Holan, City of Forest Grove
Stacy Humphrey, City of Gresham, Urban Design & Planning Dept.
Katherine Kelley, City of Gresham
Mary Kyle McCurdy, 1000 Friends of Oregon
Nancy Kraushaar, City of Wilsonville
Michelle Kunec, City of Portland
John MacArthur, OTREC-PSU
Margaret Middleton, City of Beaverton
Thaya Patton, Metro
Barbara Pizacani, PDES
Mel Rader, Upstream Public Health
Dan Rutzick, City of Hillsboro
Vivek Shandas, PSU
Vivian Shatterfield, OPAL
Lainie Smith, ODOT
Emily Tritsch, City of Hillsboro
Dyami Valentine, Washington County
Steve White, Oregon Public Health Institute

APPENDIX B. HIA Minimum Elements and Practice Standards

November 2010, Version 2
North American HIA Practice Standards Working Group, Society for the Practitioners of HIA

A health impact assessment (HIA) must include the following minimum elements, which together distinguish HIA from other processes. An HIA:

1. Is initiated to inform a decision-making process, and conducted in advance of a policy, plan, program, or project decision;
2. Utilizes a systematic analytic process with the following characteristics:
    a. Includes a scoping phase that comprehensively considers potential impacts on health outcomes as well as on social, environmental, and economic health determinants, and selects potentially significant issues for impact analysis;
    b. Solicits and utilizes input from stakeholders;
    c. Establishes baseline conditions for health, describing health outcomes, health determinants, affected populations, and vulnerable sub-populations;
    d. Uses the best available evidence to judge the magnitude, likelihood, distribution, and permanence of potential impacts on human health or health determinants;
    e. Rests conclusions and recommendations on a transparent and context-specific synthesis of evidence, acknowledging sources of data, methodological assumptions, strengths and limitations of evidence and uncertainties;
3. Identifies appropriate recommendations, mitigations and/or design alternatives to protect and promote health;
4. Proposes a monitoring plan for tracking the decision's implementation on health impacts/determinants of concern;
5. Includes transparent, publicly accessible documentation of the process, methods, findings, sponsors, funding sources, participants and their respective roles.

APPENDIX C: Practitioners' Appendix

This appendix is intended for colleagues in the field of HIA and external evaluators seeking in-depth information about the process and methods used for this HIA. The appendix describes how this HIA meets the Minimum Elements of HIA (See Appendix B) established by the North American HIA Practice Standards Working Group of the Society of Practitioners of HIA (SOPHIA) (8).

Title: Climate Smart Strategy Health Impact Assessment
Timeline: HIA screened July 2014; reporting completed in October 2014
Location: Portland Oregon Metropolitan Region (defined by the 2010 Urban Growth Boundary land use area)
Funding: Provided by the Health Impact Project, a collaboration of the Robert Wood Johnson Foundation and The Pew Charitable Trust, with in-kind staffing support provided by Oregon's Environmental Public Health Tracking Program (www.epht.oregon.gov) in the Oregon Public Health Division.
Sector(s): Land use and transportation planning; climate change
HIA type: Decision-support; comprehensive HIA including advisory committee support

Decision context

The Climate Smart Communities Scenarios (CSCS) Project underway in the Portland Oregon metropolitan (PDX metro) region is the focus of this HIA. The CSCS project is Metro Regional Government's (Metro) response to a legislative requirement to meet Oregon greenhouse gas (GHG) emissions reduction goals for small trucks and cars. These reductions will be made with technological improvements, educational and incentive programs to reduce vehicle miles traveled, and targeted land use and transportation investments. While the law was passed in an effort to mitigate climate change and reduce air pollution, Metro is also considering impacts on public health, the economy, the environment and equity as part of the planning effort. The HIA is intended to inform a December 2014 decision on the adoption of a regional scenario to meet the GHG reduction targets by Metro Council, as well as the technical and community conversations preceding the decision. *This HIA was initiated to inform a decision by the Metro Council on whether to adopt a greenhouse gas reduction-planning scenario for implementation. It was completed in October 2014 in advance of the December 2014 decision.*

Screening

The Healthy Communities Lab team received an HIA Project Request Form that covers basic screening information and serves as the first step in OHA-PHD's HIA Project Screening Process from partners at Metro in early July 2014. The Healthy Communities Lab team reviewed the information, and screened the project with partners from Metro in a meeting in mid-July.

Related work

The Climate Smart Scenarios HIA is the third in a series of HIAs conducted on a series of decisions within Metro Regional Government's Climate Smart Communities Scenarios Planning project. The previous two

HIAs were the Climate Smart Communities Scenarios HIA (2012-2013) and the Community Climate Choices HIA (2014).

In September 2011, OHA screened the Climate Smart Communities Scenarios HIA with partners at Metro and determined that an HIA could bring important health considerations to the CSCS decision-making process. In March 2012, OHA convened a group of 37 stakeholders representing planning, transportation and public health experts from around the Portland metropolitan region for a one-day workshop. Many of these stakeholders also represented local communities and vulnerable populations who will be impacted by Metro's adoption of a preferred scenario. In the meeting, OHA provided an overview of Metro's CSCS planning project, gave an introduction to health impact assessment methodology, and presented the above CSCS HIA goals.

In the March 2012 meeting, the advisory group developed a long list of potential areas to assess, and each advisory committee member shared their top five priorities for assessment. The committee also provided feedback about the kinds of information they wanted us to provide, and the timing of the information. The top six requests were: active transportation/physical activity, air quality/pollution exposure, traffic safety, health equity, the interactions of land use and public health, and the potential health cost savings/increases associated with each scenario.

The Climate Smart Communities Scenarios HIA provided analysis on the range of possible health impacts likely to come from the 144 scenarios under consideration. The scope of the assessment included four of the top six requests from the advisory committee: physical activity, air quality, traffic safety, and health equity. At the spring 2013 presentations of HIA findings and recommendations, technical advisory committee members and decision makers responded positively to the information, and requested continued support for the CSCS planning effort, and asked for additional information about land use and cost savings.

The Community Climate Choices HIA assessed the three final scenario options in each of the areas covered in the scope of the Climate Smart Communities Scenarios HIA, and added an overview of the interactions between land use and public health. At the spring 2014 presentations of HIA findings and recommendations, technical advisory committee members and decision makers responded positively to the information, and requested continued support for the CSCS planning effort, and asked for additional information about air pollution exposure and cost savings.

OHA-PHD evaluated advisory committee participation after each HIA. The 2013 Climate Smart Communities Scenarios HIA evaluation was conducted by Meghan Crane, a MPH student from Portland State University, with oversight from Stephanie Farquhar (PSU), and Karen Bishop (OHA health educator, not associated with the Healthy Communities Lab). The evaluation found that advisory committee members valued the process, and believed the results to be useful, but would have preferred more frequent and more consistent communication from the team, along with additional opportunities to engage with the project during the yearlong HIA project. The results of the evaluation were presented in a poster session at the 2012 HIA National Meeting. Using qualitative interviews and an online questionnaire, the evaluation was designed to capture preliminary impacts the HIA has had on Metro's CSCS project. The evaluation also examined changes in advisory committee perceptions of HIA, the effectiveness advisory committee engagement and participation strategies used in the CSCS HIA and developed a series of recommendations for future OHA-PHD HIA advisory committee strategies. This evaluation was instrumental in the development of stakeholder engagement, advisory committee structure, and communications plans for the Community Climate Choices HIA. A follow-up online questionnaire for the Community Climate Choices HIA demonstrated significant improvement in advisory committee perceptions of participation in the HIA.

Scope and HIA goals
Understand health impacts from change in transportation and land-use strategies and investments by modeling expected difference in disease burden between baseline (2010) and horizon year (2035); Monetize expected impacts when possible.

Health pathways
Physical activity, air quality, and traffic safety with interactions for both health equity and land use

Source(s) of evidence
Qualitative literature; Quantitative modeling using the Integrated Transport and Health Impact Model – ITHIM (11, 12); National cost-of-illness literature

Data types
Models, literature (published, peer-reviewed, grey lit, government documents, policy), websites, data

Major data sources
600+ transportation and health literature database; BRFSS; Oregon Household Activity Survey; National Household Transportation Survey; Oregon Vital Statistics; Oregon Department of Environmental Quality monitoring data; CDC Chronic Disease Cost Calculator v2.0

Data gaps identified
Integrating Air Toxics into ITHIM (see Air Quality white paper in CCC HIA Appendix F); characterizing air quality near roadway; Oregon-specific cost-of-illness; design considerations to maximize physical activity and minimize air pollution exposure; ITHIM does not allow break out by race/income.

Stakeholder involvement
A 39 member advisory committee supported this HIA (continued participation from two previous related HIAs). Advisory committee members and organizational affiliations can be found in Appendix A. Engagement with the advisory committee and advisory committee support for this project included:

- A letter notifying advisory committee of new HIA, and describing draft scope, as well as a request to provide feedback on the draft scope and proposed methodologies;
- Meeting with staff at Metro to review modeling methodology and available data;
- Partnership with OHA's Environmental Public Health Tracking Program to modify ITHIM to include Oregon-specific disease burden and assumptions where possible and run the model for Scenarios A, B, C and the Draft Approach;
- Online communication with ODOT staff to secure required data for modeling;

- Online communication with ITHIM developer (James Woodcock), and US ITHIM users in Lane County Oregon and at the State of California to review changes to the modeling tool;
- Meeting with staff at DEQ to review air quality assessment methodology, available data, initial findings, and messaging;
- Review of initial air quality findings and write-up by the Near-Roadway Pollution Program staff at the EPA; and
- Meeting with staff at OHA's Health Promotion and Chronic Disease Program to review monetization methodology, initial findings, and messaging;
- One in-person/online meeting to review initial findings and draft recommendations;
- Volunteers from advisory committee reviewed the draft report (see Overview of report review process below); and
- An online questionnaire to review recommendations and provide feedback on HIA Process.

Metro Regional Government was a key ally in each stage of each HIA. They supported the screening of each HIA project by providing staff time to share context and other critical information. They helped to develop the advisory committee, including encouraging participation of Metro technical advisory committee members. They provided data, and supported the acquisition of data we needed that they did not have. They shared internal draft versions of CSCS Project materials prior to public release, and otherwise kept us in the loop. They were actively engaged in drafting and reviewing recommendations to ensure accuracy and feasibility. They provided HIA data alongside Metro data for decision maker consideration at multiple stages within their decision making process. They secured presentation time on key advisory committee agendas prior to key decision making moments. They provided other platforms for presentation of HIA findings and recommendations where possible, including printing a poster version of the Community Climate Choices HIA key findings and recommendations for the May 2014 Joint Meeting of the JPACT and MPAC committees, at which decision makers agreed upon assumptions for the Draft Approach.

Overview of report review process

- Eleven members of the advisory committee reviewed the draft findings and developed draft recommendations;
- Six advisory committee members reviewed the full draft report:
    - Heather Gramp, OHA: Health Promotion and Chronic Disease Prevention
    - David Farrer, OHA: Toxicologist
    - Renee Hackenmiller-Paradis, OHA: Policy Analyst in the Office of the Director
    - Steve White, Oregon Public Health Institute
    - Sarah Armitage, Oregon Department of Environmental Quality: Air Quality Division
    - Kim Ellis, Metro: Senior Planner with the Climate Smart Communities Scenarios Planning Project;
- Health Impact Project (HIA funder) staff reviewed the full draft report;
- Internal OHA review included: Julie Early-Alberts (Manager, Healthy Communities Lab), Curtis Cude (Section Manager, Environmental Public Health), Bruce Gutelius (Science Officer, CP&HP), and Katrina Hedberg (Oregon State Epidemiologist).

Communication plan

- The CSS HIA report (aided by the previous related HIAs) includes full documentation of methods and sources;
- Provide written and electronic versions of the final report (with executive summary) to Metro Council, Metro's Joint Policy Advisory Committee on Transportation, and the Metro Policy Advisory Committee;
- Provide an electronic version of the final report (with executive summary) to our advisory committee;
- Post an electronic version of the report on the Healthy Communities Lab website (www.healthoregon.org/hia) for the general public;
- Provide OHA-PHD Communications with a copy of the report and talking points to support response to public and media queries;
- Present findings and recommendations to technical committees and decision makers at Metro as requested;
- Submit abstract to Transportation Research Board conference to present ITHIM findings; and,
- Submit abstracts to HIA National Meeting to present advisory committee format and monetization methodologies.

Evaluation plan

- Activities to be completed by August 2015:
- Online questionnaire with advisory committee members to review HIA process;
- In-person meetings with key stakeholders to discuss HIA process, agency-partner relationship, and initial impacts. Meetings will be scheduled with Metro staff and DEQ staff;
- Review of materials produced by Metro for instances of inclusion/communication of health data and analysis provided by the HIA;
- Review of final decision for implementation of recommendations.

Monitoring plan

- The HIA recommends that Metro monitor key health determinants such as traffic safety and active transportation rates;
- No monitoring by OHA-PHD proposed as a result of funding limitations.